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Early Mississippian Formations in Missouri

A DISSERTATION

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AND PALEONTOLOGY

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By

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Early Mississippian Formations in Missouri

By RAYMOND C. MOORE



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MISSOURI BUREAU OF GEOLOGY
AND MINES

H. A. Buehler, Director and State Geologist

ROLLA, MISSOURI

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LETTER OF TRANSMITTAL

Bureau of Geology and Mines,
Rolla, Mo., June 9, 1928.

To the President, Governor Sam A. Baker, and the Members of
the Board of Managers of the Bureau of Geology and Mines:

Gentlemen: I have the pleasure to transmit herewith a
report covering the early Mississippian formations by Mr.
Raymond C. Moore.

For a number of years this Bureau has directed a part of
its activity to more detailed studies covering the occurrence of
the various formations comprising the larger geological divisions,
and there have been published in this plan "The Stratigraphy of
the Pennsylvanian" and "The Devonian of Missouri." The
present volume is the result of a preliminary study on the part of
Dr. Moore under the direction of the late Dr. Stuart Weller of
Chicago.

The Mississippian is one of the most important stratigraphic
series in Missouri, and detailed work on each division is planned
for future publication.

Respectfully submitted,

H. A. BUEHLER,
State Geologist.



Lovers Leap, south of Hannibal, Marion County, showing the Louisiana limestone and Hannibal shale underlying Lower and Upper Burlington limestone.

Early Mississippian Formations In Missouri

BY RAYMOND C. MOORE

CHAPTER I

INTRODUCTION

One of the most interesting and important groups of rocks in Missouri is that, composed chiefly of limestone, which next underlies the coal-bearing beds of the state. Because of excellent exposures of these rocks in the bluffs along Mississippi River from southeastern Iowa to Perry County, Missouri, the name Mississippian has appropriately come to be applied to them, and the succession of formations seen along the east border of Missouri and in adjoining portions of Illinois and Iowa constitutes the type section for rocks of this age in America.

While there is a measure of uncertainty in the precise delimitation of the Mississippian from subjacent Devonian beds in some places, the upper boundary of the Mississippian in Missouri is very readily drawn. Consideration of the distinctly individual lithologic and faunal characters of the Mississippian, its sharply defined stratigraphic separation from the succeeding rocks and the evidence of a widespread interruption of sedimentation preceding Coal Measures deposition indicates that the Mississippian may properly be assigned systemic rank.

GENERAL CHARACTER AND THICKNESS

The Mississippian formations of Missouri consist mainly of limestone, but include also sandstone and shale. The limestone is mostly coarse-grained and highly crystalline, and it is commonly marked by a profusion of well preserved fossils. In general the limestone is very cherty. Shale formations are thin, clayey and sandy and are generally blue, greenish or black. Sandstone is almost negligible. The Mississippian is thus most unlike the Pennsylvanian and Permian in which shales and sandstones predominate and where limestones are thin and mostly fine-grained.

The average thickness of the Mississippian rocks in Missouri is about 500 feet, but on account of initial irregularities of deposi-

tion and the uneven manner in which pre-Pennsylvanian erosion removed parts of the Mississippian formations, the thickness varies notably from this average. In general, the depositional record appears to have been least complete in the north and to the west, the later Mississippian formations being thin or absent in these portions of the state. The total thickness increases southward, and along Mississippi River south of St. Louis the rocks of this system are at least 1,000 feet thick.

DISTRIBUTION

The area in Missouri where Mississippian beds appear at the surface or directly underlie the relatively thin concealing mantle of residual soil or glacial drift, is shown in the accompanying sketch map (Fig. 1). This area forms a continuous band across the state, broad in the northeast and southwest, rather narrow in the central part near Missouri River. In addition there is a southeasterly extension into Ste. Genevieve and Perry Counties on the east side of the Ozark highland, and numerous small outliers, generally near the main body of the Mississippian, are to be found within the highland area. Residual cherts of Mississippian age found in the central part of the Ozarks denote a former extension of some of the Mississippian formations across most, if not all, of the Ozark region.^{5A}

IMPORTANCE

Some of the most valuable mineral deposits in Missouri, namely, the lead and zinc in the southwestern part of the state, are found in Mississippian rocks. Immense quantities of easily available fine building stone and marble and rock for lime and cement, crushed stone, rip-rap, paving material and abrasives are also found in the Mississippian formations. Underground water of good quality and large amount is obtained in many places from springs and wells in rocks of Mississippian age. These formations are therefore of great economic importance. Several of the Mississippian formations that are widely recognized in other states have their type sections in Missouri.

STRUCTURE

The strata of the Mississippian have a uniformly gentle dip away from the Ozark highland where the oldest rocks in Missouri are found. Thus in northeastern Missouri the rocks are inclined to the northeast and north; in northwestern Missouri to the

northwest and in southwestern Missouri to the southwest. The Mississippian formations disappear beneath the Pennsylvanian beds and extend at varying depths below the surface, far beyond the borders of the state. The location and character of the Mississippian outcrop is dependent on the dominant anticlinal structure of the Ozark dome and the extent to which present erosion has lowered the land.

STRATIGRAPHIC RELATIONS

In spite of difficulty as regards the definition of the lower boundary of the Mississippian in Missouri, a distinct break in sedimentation may be discerned following the undoubted Devonian and preceding the deposition of strata here classed as lower Mississippian. In general, the Devonian rocks are not well represented in Missouri and in very many places Ordovician strata are found next beneath the Mississippian. Thus, there was evidently widespread and in part prolonged erosion in the Missouri region before the advance of the Mississippian seas.

The Mississippian is separated from the Pennsylvanian by an extensive, well defined unconformity. Not only were upper Mississippian deposits more or less completely removed by pre-Pennsylvanian erosion and considerable topographic unevenness locally developed, but Mississippian formations which covered the central part of the Ozarks were stripped away and underlying rocks eroded. The Pennsylvanian is found to rest transgressively on all divisions of the Mississippian and to extend to the older Paleozoic rocks.

The stratigraphic relations of the Mississippian formations among themselves are somewhat complex on account of changing relations of the sea and land and accompanying variation in conditions of sedimentation and erosion. During early Mississippian time there was especially noteworthy difference in deposition on opposite sides of the Ozarks, and in the later part of the period oscillations of the sea gave rise to disconformities and overlaps which complicate the simple succession of deposits.

The Mississippian formations of Missouri are directly continuous with the deposits of this age in adjoining states, although on account of variation in local conditions, stratigraphic subdivisions are not entirely uniform. However, on faunal and in part on very persistent lithologic characters, the major groups in the Mississippian are widely traceable, and some of the individual formations, like the cherty crinoidal Burlington and

Keokuk limestones, the commonly oolitic Spergen limestone, and the dense fine-grained St. Louis limestone are recognized far from Missouri. As shown by paleontologic and stratigraphic observations, it is known that the Missouri section includes time equivalents of the Waverly series of Ohio, the Mauch Chunk and Pocono of the Appalachian region and the well known Mountain limestone of England and the European continent.

TOPOGRAPHY

The commanding element in the topography of Missouri is the Ozark upland occupying the south central part of the state. This region, upheld mainly by resistant Cambro-Ordovician rocks, is rugged and in the highest part it has an elevation of nearly 2,000 feet. The Mississippian rocks nearly surround this upland area and form a sort of transition zone between the Ozarks and the lower, much more regular prairie plains country to the west, north and east. Southwest are the structurally distinct but semi-mountainous highlands of northern Arkansas, and southeastward the flat lowlands of the Mississippi embayment. Characteristically the Mississippian rocks form a platform bordered on the side toward the Ozarks by an escarpment most prominent in the southwest part of the state, where it is called the Springfield escarpment. This platform has in many places a very even surface that merges outward from the Ozarks with the plain carved on the weak basal shale of the Pennsylvanian. In the vicinity of the escarpment that faces the older rocks, however, there are numerous hills and deep, steep-sided valleys. The Mississippian area north of Missouri river and along the Mississippi is also marked by considerable relief, and bordering the stream there are commonly precipitous limestone cliffs. Glacial drift obscures the stratified rocks in most of northern Missouri and smooths the general land surface. Locally there are found in the Mississippian area the rounded, kettle-like depressions or the swales without outgoing surface drainage that characterize many limestone regions and mark the development of sink holes and underground drainage. These are most common in the vicinity of St. Louis and Ste. Genevieve.

PREVIOUS WORK¹

It is natural that the prominent limestone bluffs bordering Mississippi and Missouri rivers should have attracted the notice even of the pioneer voyagers who traveled along these natural

¹Reference to sources is indicated by numbers in the bibliography at the end of the report.

highways into the interior of the continent. Accordingly there is record concerning these rocks in the writings of various early explorers as far back as 1793.

In 1818 Henry R. Schoolcraft,³⁹ one of the all-around naturalists who marked the early days of science, visited Missouri in the course of exploration of the lead deposits of the Mississippi valley. His report mentions the widespread occurrence of "Secondary limestone" but contains little of geologic importance.

In 1819 Edwin James,²¹ the geologist who accompanied the Stephen Long expedition sent out by the Federal Government, made notes on the rock formations below St. Louis along the Mississippi and across the state along the Missouri. The Carboniferous age of the limestone beds below the coal formations was determined and in a geologic section drawn across the Ozark region, the westerly dip of the strata in northwest Missouri is indicated.

On the basis of observations in the upper Mississippi valley, the English naturalist, Thomas Nuttall,³³ pointed out in a paper read before the Philadelphia Academy in 1820 that fossils from the limestone bluffs along the Mississippi were apparently identical with those in the Mountain limestone of Derbyshire illustrated in Martin's *Petrifica Derbiensia*. This appears to be the earliest paleontologic notice of the richly fossiliferous Mississippian rocks in this region and an approximately correct correlation of them.

By the authorization in 1834 of the Federal Government, G. W. Featherstonhaugh¹⁵ made a mineralogical and geological survey of the Ozark Mountain region, the investigation being of interest more because this appears to be the first formal recognition by the Government of geological surveys than for the scientific results of the work. Featherstonhaugh's report mentions the wide distribution of the Carboniferous limestone in the Mississippi valley and a geological section across Missouri shows this limestone as exposed across the entire state.

These early references to the geology of Missouri are casual or indicate superficial observations and knowledge. The progress of learning is interestingly shown by the serious and somewhat heated discussion among scientists in 1822 on the "fossil" human footprints in the limestone at St. Louis, reputed to have been made by the Savior on landing from the Mississippi for a missionary voyage.

The name "Subcarboniferous" which for a time was generally applied to the rocks now called Mississippian, was introduced by David Dale Owen,³⁴ state geologist of Indiana, in the first report of the Indiana survey issued in 1838. Owen was among the first American geologists to recognize the fundamental importance of fossils in stratigraphic correlation, and by the use of such characteristic forms as *Archimedes* and *Pentremites* he correctly referred the oolites containing them to the "Subcarboniferous" rather than the familiar Jurassic oolites of Europe which lithologically they closely resembled. Under direction of the Federal Government Owen³⁶ later (1852) made extensive observations in the upper Mississippi valley, and with assistants (Shumard, Litton, Meek) who were importantly connected with subsequent geological work in Missouri made an examination of the "Subcarboniferous" limestone along Mississippi and Missouri rivers. Owen grouped the beds of this series into ten units, chiefly upon the basis of lithologic characters, and several of these units are recognized in present classification.

A state geological survey of Missouri was organized in 1853 under the direction of G. C. Swallow,⁵¹ and in the first report of this survey, issued in 1855, a general description of the Mississippian strata in the northwestern and central parts of the state appears.

The work of James Hall,¹⁸ who in 1855 was made first state geologist of Iowa, is important in connection with investigations of the Mississippian of Missouri. Hall recognized as identical the crinoidal limestone beds exposed at Burlington, Iowa, and Hannibal, Missouri, which Owen had thought to be distinct. The strata below this limestone he correlated with the Devonian Chemung formation, and he subdivided and named the rocks above the "Chemung," in ascending order, Burlington limestone, Cherty limestone, Keokuk limestone, Geode bed, Warsaw formation and St. Louis limestone.

In Illinois equally valuable additions to knowledge of these rocks were contributed by Amos H. Worthen⁷⁹ who was called in 1858 from his position as assistant to Hall to serve as state geologist of Illinois. The first volume of Worthen's somewhat voluminous reports was primarily devoted to the "Subcarboniferous." The "Chemung" of Hall was shown to belong with the succeeding formations rather than the Devonian, and the name Kinderhook was proposed. Four stratigraphic divisions above

the Kinderhook were recognized: Burlington, Keokuk, St. Louis and Chester. Later reports added descriptions of these units and made known many new fossil species found in them.

SUBDIVISIONS OF THE MISSISSIPPIAN IN MISSOURI

On the basis of stratigraphic, faunal and lithologic evidence the Mississippian rocks in Missouri may be divided into five groups; each group is composed of more or less persistent and distinctive formational units which are indicated in the following classification. It is unnecessary to discuss here the nomenclature employed by earlier workers and the development of the present classification, a subject recently reviewed in some detail by Cumings.¹⁴ As will be pointed out in describing the Warsaw, the writer believes that this unit should be allied with the beds below rather than those above, and in this respect the following classification differs from that of some geologists.

CLASSIFICATION OF THE MISSISSIPPIAN FORMATIONS

Chester group.....	Several formations
Ste. Genevieve group.....	Ste. Genevieve limestone
Meramec group.....	{ St. Louis limestone
	{ Spergen limestone
	{ Warsaw limestone
Osage group.....	{ Keokuk limestone
	{ Burlington limestone
	{ Local formations
Kinderhook group.....	Local formations

In accordance with a plan of cooperative study of Mississippian stratigraphy and correlation by the state geological surveys in the Mississippi valley the writer was given an opportunity to undertake an investigation of the Mississippian rocks in Missouri under the general direction of Professor Stuart Weller of the University of Chicago. It was planned as a result of this work, essentially reconnaissance in nature, to determine as definitely as possible the correlation of stratigraphic units in the Mississippian of different parts of Missouri and to secure a better basis for correlation of the Missouri Mississippian with that of adjoining regions. In accordance with the latter object, type sections in southeastern Iowa and western Illinois were visited, and in connection with study of Kinderhook stratigraphy additional field work was done in Illinois.

In the course of the field studies many Mississippian sections were examined, measurements being made and fossil collections

being secured from as many stratigraphic divisions as possible. The sections were chosen at convenient intervals across the Mississippian area of the state from northeast to southwest, the selection of sections studied being largely controlled by accessibility from points reached by railroads. No effort to trace the different formations by areal mapping was made nor to follow stratigraphic relations which might be worked out only by detailed field work between the places studied. Since the Mississippian area in southeastern Missouri has been the subject of studies by Professor Weller, this district was not visited by the writer nor was special attention given to the higher Mississippian formations which in Missouri are practically restricted to the southeastern area.

Field work occupied the months of June to September, inclusive, 1915, identification of the fossil collections and other office work extended over several months following. The report, prepared in 1916, has been delayed in publication. In submitting the paper for publication at this time, the writer has made some additions and minor alterations to accord with the results of more recent published information but there has been no attempt to treat the subject exhaustively.

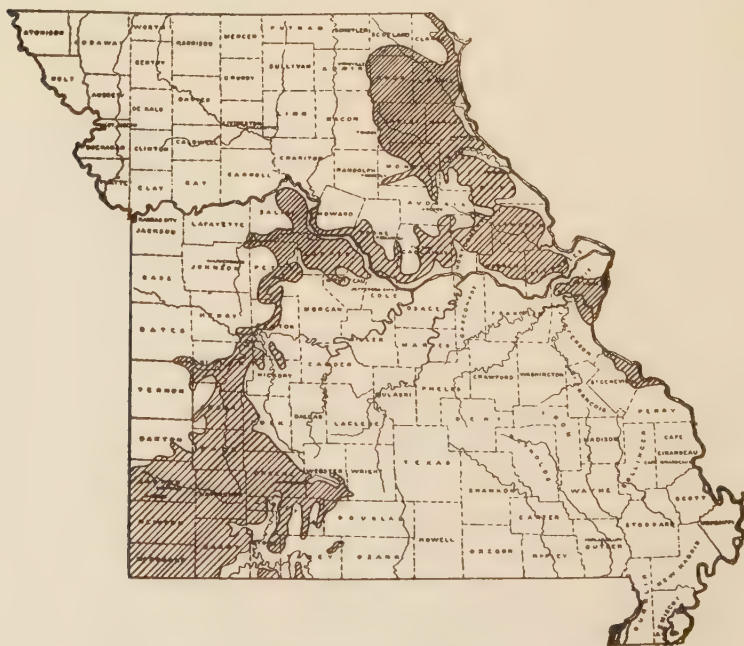


FIG. 1. Map of Missouri showing general surface outcrop of Mississippian rocks.

CHAPTER II

THE KINDERHOOK GROUP

INTRODUCTION

In the bluffs of Mississippi River "just above the village of Kinderhook," Pike County, Illinois, there is an outcrop of some eighty feet of shale and very fine calcareous sandstone, beneath capping beds of coarse-grained, crinoidal Burlington limestone. It is from this section that the name "Kinderhook," as applied to a series of Paleozoic strata in the Mississippi valley, is derived. The term was first used in 1861 by Meek and Worthen³⁰ of the Geological Survey of Illinois, who defined the group^{79a}

"to include all the beds from the base of the Burlington limestone to the top of the Black slate....*representing*....the Chouteau limestone, the Lithographic limestone, and the Vermicular sandstone and shale of the Missouri report, the so-called Chemung rocks of the Iowa report, that part of the Waverly sandstone of Ohio which overlies the Black slate of that region, and the Goniatile limestone of Indiana."

These rocks form a unit readily distinguishable lithologically and faunally from the overlying formations of the Mississippian, but it now appears that certain beds beneath the well defined horizon of the Burlington limestone should be referred to the group above the Kinderhook, and that, at least in part, the "Black shale" of the Missouri region is of Mississippian age and may be included in the Kinderhook group.

AREAL DISTRIBUTION AND THICKNESS

Strata belonging to the Kinderhook are almost co-extensive with the Mississippian in the Mississippi valley basin, but their exposure is limited by a number of factors. Because of its position at the base of the system, the Kinderhook outcrop forms a border of varying width along the side of the Mississippian area adjacent to exposed older rocks.

The most northerly outcrop of undoubted Kinderhook strata in the Mississippi valley is found in northern Iowa³⁸ not far from the Minnesota state line, but beds containing typical Kinderhook fossils are widespread in the Rocky Mountain province. A band of Kinderhook extends across Iowa in a northwest-southeast direction, the beds having a gentle southwesterly dip in this region. The outcrop is terminated a short

distance east of Mississippi River in Illinois by the overlap of the Pennsylvanian coal-bearing beds. An extensive area of Kinderhook appears in northeastern Missouri and the adjacent part of Illinois south of Quincy and Hannibal, where the Mississippi and its tributaries have cut valleys through the overlying rocks. Around the Ozark highland in central and southwestern Missouri there is a nearly continuous though very narrow Kinderhook outcrop. This strip is rather broad in certain places but it is very irregular and locally dwindles to nothing. In southeastern Missouri small patches of Kinderhook appear in Jefferson and Ste. Genevieve counties.

The average thickness of the Kinderhook in any given region is little more than 180 feet, but locally the group has more than twice this thickness. At Burlington, Iowa, the exposed Kinderhook measures 65 feet, but well borings in the vicinity indicate that the lower shale division, part of which at least appears to be referable to the Kinderhook, is 291 feet thick.^{32b} If all of this shale is Kinderhook, as inferred by Iowa geologists, the group has a total thickness of approximately 315 feet. The well records at Burlington are supplemented by numerous other borings in southeastern Iowa and northeastern Missouri which indicate the presence of a "big shale".²⁷ In the latter region the maximum thickness of beds belonging to the Kinderhook amounts to about 300 feet but owing to the lenticular, patchy character of some of the formations, the average thickness is much smaller. In east central Missouri the Kinderhook is very thin and in places absent but in Cooper and Pettis counties it maintains a uniform thickness of about 40 to 60 feet, consisting almost entirely of limestone. In southwestern Missouri and northern Arkansas the maximum thickness of the Kinderhook is 150 feet, but in many places strata of this age are absent. The Kinderhook of southeastern Missouri has a maximum known thickness of only 30 feet.

GENERAL RELATIONS

The Kinderhook comprises relatively a small portion of the deposits of Mississippian age in Missouri. It represents, however, a very important interval in the history of the Mississippi valley basin, and the stratigraphic interpretation of the relations of deposits of one region to the disconnected formations of an adjoining area presents an interesting problem.

The Kinderhook is variously composed lithologically in the different regions where it appears at the surface. It contains dense, compact, almost lithographic limestone, medium-grained crystalline limestone, oolite, dolomitic limestone, sandstone and shale. In general, the proportion of clastic material in the Kinderhook is much greater than in overlying divisions of the Mississippian except the Chester.

SUBDIVISIONS

The Kinderhook of Missouri, in contrast to the overlying Osage group, is distinguished by a diversity of lithologic, faunal and stratigraphic characters. Conditions of deposition during Kinderhook time appear to have varied greatly from one place to another and in the same place with the lapse of time. Consequently the history of the Kinderhook is more or less unlike in different regions. It is impossible to trace the stratigraphic divisions and faunas of one region without change into adjoining districts. The three-fold subdivision of the Kinderhook suggested by Swallow,^{51a} which has been applied in different parts of the state without recognition of the true character of the deposits included in the Kinderhook, does not conform with the observed facts. The following table indicates the stratigraphic units which have been recognized in various portions of Missouri and adjoining states and represents the correlation of the different deposits on the basis of evidence at hand.

PREVIOUS WORK

The earliest study of the Kinderhook deposits in Missouri was that of Swallow⁵¹ and his associates in the first geological survey of the state (1855). Detailed examinations of the Kinderhook in Cooper county were made by Swallow,^{51b} in Marion county by Shumard,⁴⁴ and in Moniteau county by Meek.²⁹ A second report (1873) contains descriptions of the Kinderhook in Warren county by Broadhead,⁶ in Saline and Morgan counties by Meek,³¹ and in Ozark and Wright counties by Shumard.⁴⁵ Notice of the Kinderhook strata in Cedar and Howard counties is contained in a report by Broadhead published in 1874.

Official examination of the geology of Missouri since 1900 has been carried on by the Missouri Bureau of Geology and Mines. The most important contribution to the stratigraphy of the Kinderhook beds in the state during the earlier period of this

organization is the report on the geology of Greene county by Shepard.⁴² This affords detailed information on the general character, areal distribution and stratigraphic relations of the various members of the Kinderhook in Greene county and adjoining portions of Polk, Webster and Christian counties. It is the only areal study in southwest Missouri which includes a description of the lowermost strata of the Mississippian, and in view of the careful nature of the work, it is of corresponding value.

Among the later publications (2nd series) of the Bureau the most important with reference to the Kinderhook are the geologic reports of Moniteau and Pike counties, by Van Horn⁵⁸ and Rowley,³⁷ respectively. Both of these counties contain very typical outcrops of the Kinderhook beds. The report on Pike county is of especial value on account of the faunal study of the various formations which covers the work of many years. General reference to the Kinderhook formations of the state is included in the report on the lime and cement resources of Missouri by Buehler.⁹

In addition to these publications bearing more or less directly on the stratigraphy of the Kinderhook in different regions, discussions of the physiography of Missouri, by Marbut,²⁸ and of the paleontology of the state by Keyes,²³ consider the Kinderhook. An account of the underground waters of the state by Shepard,⁴³ describes the Kinderhook group.

Of special value in the study of the Kinderhook in Missouri are Weller's contributions describing the faunas of various formations of this group. These constitute the only information available with regard to the faunas of some of the formations. The first⁶² of these studies describes the fauna of the Northview formation in the southwestern part of Missouri. The second⁶³ and third⁶⁵ are devoted to the divisions of the Kinderhook at Burlington, Iowa, which are very fossiliferous and afford valuable material for comparison with the Kinderhook beds in Missouri. The fauna of the Glen Park limestone of southeastern Missouri, which is quite unlike that of other faunas in the state, is described in the fourth paper.⁶⁸ Additional papers discussing the stratigraphy of the Kinderhook in different portions of Missouri are listed in the bibliography. An invaluable aid in paleontologic study is found in Weller's monograph⁷¹ on the Mississippian brachiopods of the Mississippi valley basin which includes careful descriptions and illustrations of known species of these horizon markers in the Kinderhook beds of Missouri.

CLASSIFICATION

The development of the present classification of the Kinderhook beds has been a matter of rather slow growth, resulting from the studies of a number of geologists. A brief consideration of what may be termed the history of the Kinderhook will be of assistance in the understanding of Kinderhook stratigraphy.

David Dale Owen,³⁵ who directed the first adequate survey of any of the rocks of the Mississippi valley, very early came to the conclusion that the beds in this region overlying the "black slate" belonged in the Carboniferous system. He regarded the lower 60 feet of the section at Burlington, Iowa, below the crinoidal (Burlington) limestone, as the lowest division of the Subcarboniferous. This correct correlation of the "argillo-calcareous" group with the beds now called Mississippian is of interest in view of the later misapprehension of other geologists.

De Verneuil,⁸² who made many contributions to the early study of American geology, also recognized the Carboniferous aspect of the beds now included in the Kinderhook. He rightly concluded that the Waverly group of Ohio belonged to the Carboniferous and pointed out that formations in the Mississippi valley above the black shale are of the same age, comparing the beds in question with the lower Carboniferous of Europe. Fossil goniatites from the Rockford limestone of Indiana sent to De Verneuil⁸³ were pronounced equivalent in age to similar fossils from the Mountain limestone of England and Belgium.

G. C. Swallow^{51a} correlated the beds overlying the "black slate" with the Chemung division of the Devonian, but he was not certain that the beds were Devonian, as he excluded the "Chemung" from that system in description of the series. He divided the group into three formations which he believed distinguishable throughout most of Illinois, Iowa and Missouri: from below upward (a) Lithographic limestone, (b) Vermicular sandstone and shale and (c) Chouteau limestone.

When James Hall,¹⁸ pronounced the lower beds at Burlington, Iowa, equivalent to the Chemung of New York, the correlation seemed fairly certain, for he was thoroughly familiar with the eastern group. Hall confused the yellow sandstone at Burlington with similar beds of undoubted Devonian age farther north in Iowa, and was thus misled to assign both to the Devonian.

In a description of the rocks at Burlington written in 1860, C. A. White⁷² noticed the very close faunal similarity of the

"Chemung" to the higher beds of recognized Carboniferous age at Burlington, some of the brachiopods of the two divisions being identical. He believed, however, that although the lower beds at Burlington might be the geologic equivalent of the Chemung of New York, they might well be younger than the typical Chemung, the fauna of the latter having migrated westward after the close of the New York Chemung.

Meek and Worthen,³⁰ in a careful study of the problem undertaken at the same time, showed the lack of any specific identity between the fossils of the western "Chemung" and the typical Upper Devonian of the east. They emphasized the new elements in the fauna suggestive of the Carboniferous and correlated the group with that system. The name Kinderhook group, as already mentioned, was proposed at this time.

Broadhead⁷ and subsequently Williams^{75a} proposed the name "Chouteau group" to replace the inappropriate term used by Swallow. As there is no doubt of the stratigraphic equivalence of the "Chouteau group" to the Kinderhook, the latter name must be used on the ground of priority.

As now recognized the Kinderhook group includes a number of more or less local formations which have been named from the region of their typical development. The general character of these formations and the position of the group as a whole are well understood, but the faunal and stratigraphic relations of various portions of the Kinderhook are by no means completely investigated.

THE TYPE SECTIONS OF THE KINDERHOOK

The sections of the Kinderhook designated by Meek and Worthen, though not far distant from typical exposures of the group in northeastern Missouri, exhibit quite distinct lithologic and faunal characters. A knowledge of these features is almost prerequisite to an adequate conception of the relations of the Kinderhook in Missouri.

Kinderhook, Illinois. Kinderhook is on the east side of Mississippi River opposite Hannibal, Missouri. The section which is exposed "at the point of the bluff, just above the village" is interesting in its resemblance to Kinderhook sections in southeastern Iowa and in its relations to the outcrops across the river, in Missouri. The most complete exposure of the beds is found in a small deep ravine in the Mississippi bluffs just south of McKerney Creek. At this point the following section, agreeing essentially with that of Worthen⁸⁰ is observed.

(1) Section North of Kinderhook, Pike County, Illinois

		Thickness	
		Feet.	Inches.
Drift and loess.			
Osage group.			
Burlington limestone (Lower)			
4. Limestone, gray, coarse crystalline, crinoidal, massive. (Exposed)		20	
<i>Disconformity</i>			
Kinderhook group.			
Hannibal formation ¹ .			
McKerney limestone member.			
3. Limestone, bluish drab, fine-grained, compact, with sharply conchoidal fracture, slightly irregular bedding and partially altered to brown, magnesian limestone.		6	
English River (?) sandstone member.			
2. Sandstone, blue, weathering green and brown, very fine-grained, massive, calcareous, fossiliferous. Weathers characteristically along joint planes obliquely inclined to bedding.		42	
Maple Mill (?) shale member.			
1. Shale, blue, sandy, argillaceous, fairly uniform in texture, containing thin sandstone beds in the upper part. (May include part of Saverton shale in lower part.) Exposed.		43	

The upper very fine-grained, dense limestone (Bed 3) of the Kinderhook section, which is here termed the McKerney limestone, is very hard and "lithographic" in texture, breaking with sharply conchoidal fracture. It is almost entirely lacking in organic remains, only two species of brachiopods, *Paryphorhynchus striatocostatum* and *Productella pyxidata* (?) having been reported from it.

The middle sandstone member contains a fauna of considerable interest, analysis of which, supported by stratigraphic evidence, is deemed to afford basis for designating it, at least tentatively, the English River sandstone. Lithologically, the sandstone is remarkable on account of the fineness of its grain and the evenness of its texture. Measurement under the microscope shows that the average diameter of the sand grains in this member is about 0.03 mm. According to Worthen⁸⁰ the sandstone "abounds in fossil shells belonging to the genera *Aviculopecten*, *Spirifer*, *Orthis* and *Productus*," Weller⁶⁷ has made collections from this bed which have been supplemented by the writer. The fossils are distributed somewhat sparingly throughout the sandstone division but are most abundant in a rather narrow zone about 25 feet from the top. The species identified are given in Faunal Table I.

The lower shale at Kinderhook has yielded no fossils. The name Maple Mill is employed from correlation with the shale underlying the English River sandstone in southeastern Iowa.

¹Formation names have not previously been applied to the Kinderhook at its type locality.

Burlington, Iowa. Another of the sections designated by Meek and Worthen as most typical of the Kinderhook, includes "the beds between the Burlington limestone and a point beneath the level of Mississippi River," at Burlington, Iowa. The strata here are much more fossiliferous than at Kinderhook and the section is, in many respects, better suited to serve as the type for this group. Because of the excellent exposures and because of abundant fossils the Kinderhook at Burlington has been studied by several geologists. The following description of the section agreeing essentially with that published by previous workers is given by Van Tuyl,^{59a} formation names being introduced by the writer.

(2) Section of Kinderhook Beds at Prospect Hill, Burlington, Iowa

		Thickness	
		Feet.	Inches.
Osage group			
Burlington limestone (Lower)			
8.	Limestone, gray to brown, massive, crinoidal, cherty . . .		
Sedalia limestone (?)			
7.	Limestone, soft, buff to brownish, dolomitic; with casts of fossils; grading up into Lower Burlington limestone. . .	5	
<i>Disconformity ?</i>			
Kinderhook group			
Chouteau limestone			
6.	Limestone, white, oolitic, scaling off obliquely on weathered surfaces.	3	
Hannibal formation			
Prospect Hill sandstone member			
5.	Sandstone, soft, fine-grained, drab weathering buff; shaly in upper part; some seams filled with casts of fossil shells; bearing occasional plant remains.	6	
McKerney limestone member			
4.	Limestone, upper one or two feet brownish and dolomitic. Lower layers consisting of dense gray lithographic-like limestone mottled with small patches of brownish dolomite which in some instances follow small fractures. Small calcite geodes occur in the dolomitic areas, and occasional small pockets of sphalerite appear in both the limestone and dolomite.	10	
3.	Limestone. Lower half coarse-grained and filled with <i>Chonetes</i> . Upper half oolitic. Upper surface very undulating, although there is a transition from the oolite into the limestone above. Contact with bed below in places irregular.		8
English River sandstone member			
2.	Sandstone, fine-grained, soft, drab, weathering buff, massive; with occasional thin intercalated layers of shale; upper two feet filled with casts of fossils, most abundant of which is <i>Chonopectus fischeri</i>	22	6
Maple Mill shale member			
1.	Shale, bluish, argillaceous, locally calcareous, drab, sparsely fossiliferous, grading into the bed above. The greatest thickness of this bed is in the old clay pit, where 19 feet are shown. Between the bed of the pit and the level of Mississippi River, about 14 feet more is concealed. Exposed.		19

Bed 1, referred to the Maple Mill shale is a very uniform, soft, blue or green shale which is probably considerably thicker than its exposed portion as shown in the preceding section. It had long been regarded as barren of organic remains but in the excavation of the clay pits of a brick plant, Calvin and Udden^{64a} succeeded in collecting a small fauna. This has been identified by Weller as recorded in Faunal Table I.

Bed 2, commonly called the *Chonoepectus* sandstone because of the abundance of *Chonoepectus fischeri* which literally crowd the upper portion of the bed, corresponds to the English River sandstone of Washington county, Iowa. Though soft and friable the sandstone is very massive in some exposures. About 80 per cent of pure quartz sand is contained in the rock, the remainder being lime, magnesium carbonate, etc. The fineness of the quartz grains as seen under a microscope is striking; a specimen studied by the writer showing an average diameter of the individual grains of 0.05 mm. The lower part of the sandstone is more shaly and slightly softer than the upper part. The fauna of the member, which is large and distinctive, is restricted almost wholly to the upper five or six feet. As identified by Weller the fauna of this sandstone is listed in Faunal Table I.

Bed 3 is a very thin horizon that in many places is represented by two distinct bands, the lower the "Chonetes Band," an impure buff or brownish limestone crowded with *Chonetes gregarius*, the upper the "oolitic band," an impure oolitic limestone, locally absent. Because of its lithologic character and relations to adjacent strata, this bed is regarded as a part of the McKerney limestone member. The fauna of Bed 3 is very closely related to that of the subjacent English River sandstone (see Faunal Table I).

Bed 4, which may be regarded as the main equivalent of the McKerney limestone, comprises an irregularly bedded division of dark gray, very compact, fragmental limestone, lithologically similar to the upper limestone at Kinderhook, Illinois. Its fauna is not large but contains a number of species not recognized as Kinderhook.

In lithologic character the "upper yellow sandstone," Bed 5, here designated the Prospect Hill sandstone, is not unlike the *Chonoepectus* sandstone, Bed 2, but it may be distinguished by its slightly lighter color and denser texture. In weathered outcrops it appears as a single massive layer, or it may weather in thin, somewhat lenticular beds. The upper 2 or 3 feet consist

of distinctly softer yellow sandstone. In places the fossil casts are literally crowded together, but with few exceptions they are different from those observed in the *Chonopectus* fauna. The bed contains a large Chouteau element in its fauna but it is lithologically and faunally more closely allied to the Hannibal formation at Burlington. The fauna of this member as represented by collections at Burlington and on Flint River in southeastern Iowa is shown in Faunal Table I.

Bed 6, comprising the uppermost division of the Kinderhook at Burlington, as the stratigraphic boundaries of the group are here drawn, is a conspicuous bed of light gray to white, oolitic limestone of rather uniform lithologic texture. Fossils are abundant and are often beautifully preserved, the fauna being closely allied to that of the subjacent sandstone. The pelecypod element of the latter, however, is lacking (See Faunal Table I).

REGIONAL DEVELOPMENT OF THE KINDERHOOK

Study of the Kinderhook beds of Missouri may be divided naturally and conveniently on a basis of the different regional development of the group. This variation includes marked changes in lithologic characters, in the stratigraphic succession of the various formational units, and in faunas. The Kinderhook areas are more or less separated in outcrop, and early Mississippian physical history in each district appears to have been somewhat different. For example, the Chouteau limestone of central Missouri which may be distinguished readily by its peculiar lithologic and faunal characters, is not recognized in southeastern Missouri, nor on the south flank of the Ozarks. In place of the Chouteau, which in central Missouri comprises practically the entire Kinderhook section, are other formations with different lithologic characters, faunas and stratigraphic relations. The grouping into subprovinces within the state on the differences which have been noted, does not, however, imply the entire distinction of one region from the other. On the contrary, the inter-relations are in some respects, at least, rather intimate.

The regional provinces of the Kinderhook in Missouri which are suggested on the features mentioned are as follows:

- (1) The northeastern Missouri region, including adjacent parts of Iowa and Illinois.

- (2) The central Missouri region.

(3) The southwestern Missouri region, including adjacent parts of northern Arkansas.

(4) The southeastern Missouri region.

In northeastern Missouri Kinderhook strata outcrop south of Lewis and Knox counties and across the river in Illinois. South of Quincy they extend on both sides of the Mississippi River without essential break to the Cap au Gres fault near the south border of Lincoln County, Missouri, and southern Calhoun County, Illinois.

The typical development of the central Missouri Kinderhook is found in Cooper, Pettis, Boone and Howard counties in the northwest central portion of the state. Parts of Saline and Moniteau counties and the territory on the north side of Missouri River east of Boone county contain small exposures of the Kinderhook as far as St. Charles county.

The southwestern Missouri region contains a very irregular belt of Kinderhook, the important outcrops occurring in Polk, Greene, Webster, Wright, Christian, Douglas, Taney, Stone, Barry and McDonald counties. In Benton, St. Clair and Cedar counties the Kinderhook is intermediate in character between the southwest and the central districts. A portion of northern Arkansas, extending on the south flank of the Ozark dome, may be included with the southwestern Missouri district.

The southeastern Missouri district is separated geographically from other districts and somewhat individual in its character. It includes small exposures of Kinderhook strata in Jefferson, Ste. Genevieve and Perry counties.

Faunal Table I.—Fauna of the Type Kinderhook Sections¹

Beds	Kinderhook		Burlington					
	2	3	1	2	3	4	5	6
<i>Sponge</i>								
Dictyophyton sp.	—	—	x	—	—	—	—	—
<i>Corals</i>								
Zaphrentis sp. 1, 2	—	—	—	—	—	—	—	x
<i>Crinoids</i>								
Stems	—	—	x	x	—	—	—	—
<i>Worms</i>								
Burrows	—	—	—	x	—	—	—	—

FAUNAL TABLE I—Continued.

Beds	Kinderhook		Burlington					
	2	3	1	2	3	4	5	6
<i>Bryozoans</i>								
Fenestella sp.	—	—	—	x	—	—	—	—
Ptilopora sp.	—	—	—	—	—	—	x	—
<i>Brachiopods</i>								
Lingula membranacea Winchell.	—	—	—	x	—	—	—	—
Lingula sp.	—	—	x	—	—	—	—	—
Orbiculoidea capax (White)	—	—	—	x	—	—	—	—
Orbiculoidea sp. 1.	—	—	x	—	—	—	—	—
Orbiculoidea sp. 2.	x	—	—	—	—	—	—	—
Crania sp.	x	—	—	—	—	—	—	—
Rhipidomella burlingtonensis (Hall)	—	—	—	—	—	—	—	x
Rhipidomella missouriensis (Swallow)	—	—	—	—	x	—	—	—
Rhipidomella thiemei (White)	x	—	—	—	x	—	x	x
Rhipidomella sp. cf. R. burlingtonensis (Hall)	—	—	x	—	—	—	—	—
Rhipidomella n. sp.	—	—	—	x	—	—	—	—
Rhipidomella sp.	x	—	—	—	—	—	—	—
Schizophoria subelliptica (W. & W.)	—	—	—	—	—	—	—	x
Schizophoria sp. cf. S. swallowi (Hall)	—	—	—	x	—	—	—	—
Schizophoria n. sp.	—	—	x	—	—	—	—	—
Schellwienella crenulicostata Weller.	—	—	—	—	—	—	x	x
Schellwienella inaequalis (Hall)	—	—	—	x	—	—	x	x
Schellwienella inflata (W. & W.)	—	—	—	—	—	—	—	x
Schellwienella planumbona Weller.	—	—	—	—	—	—	—	x
Schellwienella n. sp.	x	—	—	—	—	—	—	—
Schellwienella sp. 1.	—	—	—	—	x	—	—	—
Schellwienella sp. 2.	—	—	—	—	—	—	x	—
Leptaena analoga (Phillips)	—	—	—	—	—	—	x	x
Chonetes alatus Moore.	x	—	—	x	x	—	—	—
Chonetes burlingtonensis Weller.	—	—	—	—	—	—	—	x
Chonetes geniculatus White.	x	—	—	—	—	—	—	—
Chonetes glenparkensis Weller.	—	—	—	—	—	—	x	—
Chonetes gregarius Weller.	—	—	—	—	x	—	—	—
Chonetes illinoisensis Worthen.	x	—	—	x	—	—	—	—
Chonetes logani N. & P.	—	—	—	—	—	—	—	x
Chonetes sp. cf. C. geniculatus White.	—	—	—	x	—	—	—	—
Chonetes sp. cf. C. gregarius Weller.	—	—	—	—	—	—	x	—
Chonetes sp. cf. C. burlingtonensis Weller.	—	—	—	—	—	—	x	—
Productella pyxidata (Hall)	—	x	—	—	—	—	—	—
Productella sp.	—	—	x	—	—	—	—	—
Productus arcuatus Hall.	—	—	—	—	—	—	x	x
Productus curtirostris Winchell.	x	—	—	x	—	—	—	—
Productus mesicostalis Weller.	x	—	—	x	—	—	—	—
Productus ovatus Hall.	—	—	x	x	—	—	—	x
Productus parvulus Winchell.	—	—	—	—	—	—	x	—
Productus sp. cf. P. ovatus Hall.	—	—	—	—	—	—	x	—

FAUNAL TABLE I—Continued.

Beds	Kinderhook		Burlington					
	2	3	1	2	3	4	5	6
<i>Brachiopods—Cont'd</i>								
<i>Productus</i> n. sp.	—	—	—	x	—	—	—	—
<i>Productus</i> sp. 1.	—	—	x	—	—	—	—	—
<i>Productus</i> sp. 2.	—	—	—	—	—	—	x	—
<i>Pustula concentrica</i> (Hall)	?	—	—	x	—	—	?	—
<i>Pustula morbilliana</i> (Winchell)	—	—	—	—	—	—	x	—
<i>Pustula nummularis</i> (Weller)	—	—	—	x	—	—	—	—
<i>Pustula sublaevis</i> (Weller)	x	—	—	—	—	—	—	—
<i>Avonia</i> (?) <i>blairi</i> (Miller)	—	—	—	—	—	—	x	—
<i>Chonopectus fischeri</i> (N. & P.)	—	—	—	x	x	x	—	—
<i>Camarophorella lenticularis</i> (W. & W.)	—	—	—	—	—	—	x	—
<i>Camarotoechia</i> sp.	—	—	—	—	—	—	—	x
<i>Rhynchonella</i> sp.	—	—	—	—	x	—	—	—
<i>Paryphorhynchus striatocostatus</i> (M. & W.)	—	x	—	—	?	x	—	—
<i>Paryphorhynchus transversum</i> Weller	x	—	—	x	—	—	—	—
<i>Shumardella missouriensis</i> (Shumard)	—	—	—	—	—	—	x	—
<i>Rhynchopora pustulosa</i> (White)	—	—	—	—	x	x	—	—
<i>Allorhynchus heteropse</i> (Winchell)	—	—	—	x	x	x	—	—
<i>Allorhynchus unicum</i> (Winchell)	—	—	—	—	—	x	—	—
<i>Dielasma allei</i> (Winchell)	—	—	—	—	—	—	x	x
<i>Cranaena</i> ? sp.	—	—	—	—	—	—	x	x
<i>Spirifer biplicatus</i> Hall	—	—	—	x	o?	—	—	—
<i>Spirifer biplicoides</i> Weller	—	—	—	—	—	—	x	x
<i>Spirifer louisianensis</i> Rowley	—	—	—	—	—	—	?	—
<i>Spirifer marionensis</i> Shumard	?	—	—	?	—	—	—	—
<i>Spirifer osagensis</i> Swallow	—	—	—	—	—	—	?	—
<i>Spirifer platynotus</i> Weller	—	—	—	o	o	—	x	x
<i>Spirifer subrotundus</i> Hall	x	—	—	x	x	—	—	—
<i>Spirifer</i> sp. 1.	—	—	—	—	x	—	—	—
<i>Spirifer</i> sp. 2.	—	—	—	—	—	—	x	—
<i>Brachythyris burlingtonensis</i> Weller	—	—	—	—	—	—	x	—
<i>Brachythyris chouteauensis</i> (Weller)	—	—	—	—	—	—	—	x
<i>Syringothyris extenuata</i> (Hall)	x	—	—	x	x	—	—	—
<i>Syringothyris halli</i> Winchell	—	—	—	—	—	x	—	—
<i>Syringothyris</i> n. sp.	—	—	—	—	—	—	x	—
<i>Syringothyris</i> sp.	—	—	—	—	x	—	—	—
<i>Delthyris</i> sp.	—	—	—	—	—	—	x	—
<i>Reticularia cooperensis</i> (Swallow)	—	—	—	x	—	—	x	—
<i>Ambocoelia parva</i> Weller	—	—	—	—	—	—	x	—
<i>Cyrtina acutirostris</i> (Shumard)	—	—	—	—	—	—	?	—
<i>Spiriferina</i> ? sp.	—	—	—	—	—	—	x	—
<i>Eumetria altirostris</i> (White)	—	—	x	x	—	—	—	—
<i>Nucleospira barrisi</i> White	—	—	—	—	—	—	x	—
<i>Athyris crassicaudalis</i> White	—	—	—	—	—	—	x	x
<i>Athyris lamellosa</i> (L'Eveille)	—	—	—	—	—	—	x	—

FAUNAL TABLE I—Continued.

Beds	Kinderhook		Burlington					
	2	3	1	2	3	4	5	6
<i>Brachiopods—Cont'd</i>								
Athyris sp.	—	—	—	—	—	—	x	—
Cliothyridina tenuilineata (Rowley)	—	—	—	—	—	—	—	?
Composita ? corpulenta (Winchell)	—	—	—	x	—	—	—	—
<i>Pelecypods</i>								
Sphenotus bicarinatus (Winchell)	—	—	—	x	—	—	—	—
Sphenotus bicostatus Weller	—	—	—	x	—	—	—	—
Sphenotus cylindricus (Winchell)	—	—	—	—	—	—	x	—
Sphenotus iowensis (Winchell)	—	—	—	x	—	—	—	—
Sphenotus rigidus (W. & W.)	—	—	—	x	—	—	—	—
Promacrus cuneatus Hall	—	—	—	x	—	—	x	—
Grammysia amygdalina (Winchell)	—	—	—	x	—	—	cf.	—
Grammysia plena Hall	x	—	—	x	—	—	—	—
Grammysia hannibalensis (Shumard)	—	—	—	—	—	—	?	—
Glossites ? burlingtonensis Weller	—	—	—	x	—	—	—	—
Glossites ellipticus (Winchell)	—	—	—	x	—	—	—	—
Cardiopsis megambonata Winchell	—	—	—	x	—	—	—	—
Dexiobia halli Winchell	—	—	—	—	—	—	x	—
Dexiobia ovata (Hall)	—	—	—	—	—	—	x	—
Dexiobia sp.	—	—	—	—	—	—	x	—
Edmondia aequimarginalis Winchell	—	—	—	x	—	—	—	—
Edmondia burlingtonensis W. & W.	—	—	—	x	—	—	—	—
Edmondia jejuna (Winchell)	—	—	—	x	—	—	—	—
Edmondia nitida Winchell	—	—	—	x	—	—	—	—
Edmondia nuptialis Winchell	—	—	—	—	—	—	x	—
Edmondia quadrata (W. & W.)	—	—	—	x	—	—	—	—
Edmondia strigillata Winchell	—	—	—	—	—	—	x	—
Edmondia sp.	—	—	—	—	—	—	x	—
Pteria strigosa (White)	x	—	—	x	—	—	—	—
Nucula iowensis W. & W.	—	—	—	°	—	—	x	—
Palaeoneilo barrisi (W. & W.)	—	—	—	—	—	—	x	—
Palaeoneilo microdonta (Winchell)	—	—	—	—	—	—	x	—
Leda saccata (Winchell)	—	—	—	—	—	—	x	—
Parallelodon cochlearis (Winchell)	—	—	—	x	—	—	—	—
Parallelodon modestus (Winchell)	—	—	—	x	—	—	—	—
Parallelodon parvus (W. & W.)	—	—	—	—	—	—	x	—
Parallelodon sp. cf. P. blairi (Miller)	x	—	—	—	—	—	—	—
Spathella phaselia (Winchell)	—	—	—	—	—	—	x	—
Spathella ventricosa (W. & W.)	—	—	—	x	—	—	—	—
Mytilarca fibristriata (W. & W.)	—	—	—	x	—	—	—	—
Mytilarca occidentalis (W. & W.)	—	—	—	x	—	—	—	—
Liopteria spinalata (Winchell)	—	—	—	x	—	—	—	—
Liopteria undulata M. & W.	x	—	—	—	—	—	—	—
Posidonomya ? ambigua Winchell	—	—	—	x	—	—	—	—
Pteronites whitei Winchell	x	—	—	°	—	—	—	—

FAUNAL TABLE I—Continued.

Beds	Kinderhook		Burlington					
	2	3	1	2	3	4	5	6
<i>Pelecypods—Cont'd</i>								
Schizodus burlingtonensis Weller	—	—	—	x	—	—	—	—
Schizodus iowensis Weller	—	—	—	x	—	—	—	—
Schizodus trigonalis (Winchell)	—	—	—	—	—	—	x	—
Schizodus sp. 1	—	—	—	—	—	—	x	—
Schizodus sp. 2	—	—	—	—	o	—	—	—
Schizodus sp. 3	—	—	—	—	—	o	—	—
Aviculopecten caroli Winchell	—	—	—	x	—	—	—	—
Aviculopecten macwhorteri Worthen	x	—	—	—	—	—	—	—
Aviculopecten tenuicostus Winchell	—	—	—	x	—	—	—	—
Aviculopecten iowensis Miller	—	—	—	—	x	—	—	—
Aviculopecten sp. 1	x	—	—	—	—	—	—	—
Aviculopecten sp. 2	—	—	x	—	—	—	—	—
Aviculopecten sp. 3	—	—	—	o	—	—	x	—
Aviculopecten sp. 4	—	—	—	—	—	—	x	—
Pterinopecten nodocostatus (W. & W.)	—	—	—	—	—	—	x	—
Pterinopecten sp. cf. P. laetus Hall	x	—	—	x	—	—	—	—
Pterinopecten sp. cf. P. sedaliensis (Miller)	—	—	—	—	—	—	x	—
Pterinopecten ? sp.	—	—	—	x	—	—	—	—
Pernopecten cooperensis (Shumard)	x	—	—	—	—	—	x	x
Pernopecten sp. cf. cooperensis (Shumard)	—	—	—	o	—	—	—	o
Pernopecten circulus Hall	—	—	—	—	—	—	—	o
Pernopecten sp.	—	—	—	—	o	—	—	—
Goniophora jennae Winchell	x	—	—	x	—	—	—	—
Allorisma sp.	—	—	—	—	—	o	—	—
Lithophagus minutus Weller	—	—	—	—	—	—	x	—
Cypricardinia sulcifera (Winchell)	—	—	—	x	—	—	x	—
Cypricardella leptogaster (Winchell)	—	—	—	—	x	—	—	—
Conocardium pulchellum W. & W.	—	—	—	—	—	—	—	x
<i>Gastropods</i>								
Bellerophon bilabiatus W. & W.	—	—	—	x	—	—	—	—
Bellerophon panneus W. & W.	—	—	—	x	—	—	—	—
Bellerophon vinculatus W. & W.	—	—	—	x	—	—	—	—
Bellerophon sp. cf. B. blairi M. & G.	—	—	—	—	—	—	x	—
Bellerophon sp. 1	x	—	—	—	—	—	—	—
Bellerophon sp. 2	—	—	—	—	—	—	x	—
Bellerophon sp. 3	—	—	—	—	—	—	—	x
Bellerophon sp. 4	—	—	—	—	o	—	—	—
Patellostium scriptiferum (White)	x	—	—	x	—	—	—	—
Bucanopsis deflecta Weller	—	—	—	x	—	—	—	—
Bucanopsis perelegans (W. & W.)	—	—	—	—	—	—	x	—
Porcellia crassinoda W. & W.	—	—	—	x	—	—	—	—
Porcellia obliquinoda White	—	—	—	x	—	—	—	—
Porcellia rectinoda Winchell	—	—	—	x	—	—	—	—
Porcellia n. sp.	—	—	x	—	—	—	—	—

FAUNAL TABLE I—Continued.

Beds	Kinderhook		Burlington					
	2	3	1	2	3	4	5	6
<i>Gastropods—Cont'd</i>								
Platyschisma barrisi (Winchell).....	—	—	—	x	—	—	—	—
Platyschisma depressum Weller.....	—	—	—	x	—	—	—	—
Platyschisma sp.....	—	—	x	—	—	—	—	—
Straparollus ammon (W. & W.).....	—	—	—	x	—	—	—	—
Straparollus macromphalus Winchell.....	—	—	—	x	—	—	—	—
Straparollus obtusus (Hall).....	—	—	—	—	—	—	—	x
Straparollus sp. 1.....	x	—	—	—	—	—	—	—
Straparollus sp. 2.....	—	—	—	—	x	—	—	—
Straparollus sp. 3.....	—	—	—	—	—	—	x	—
Phanerotinus paradoxus Winchell.....	—	—	—	x	—	—	x	—
Euomphalus angularis (Weller).....	—	—	—	x	—	—	x	—
Pleurotomaria ? quinquedulcata Winchell.....	—	—	—	—	—	—	—	x
Pleurotomaria sp.....	—	—	—	—	—	—	—	x
Pleurotomaria sp.....	x	—	—	—	—	—	—	—
Strophostylus bivalve (W. & W.).....	—	—	—	x	—	—	x	x
Naticopsis depressa Winchell.....	—	—	—	x	—	—	—	—
Sphaerodoma pinguis (Winchell).....	x	—	—	x	—	—	—	—
Loxonema oligospirum Winchell.....	—	—	—	x	—	—	—	—
Loxonema shumardanum (Winchell).....	—	—	—	x	—	—	—	—
Loxonema sp. 1.....	x	—	—	—	—	—	—	—
Loxonema sp. 2.....	—	—	—	x	—	—	—	—
Loxonema sp. 3.....	—	—	—	—	x	—	—	—
Holopea conica Winchell.....	—	—	—	—	x	—	x	—
Holopea subconica Winchell.....	—	—	—	—	x	—	—	—
Holopea sp.....	—	—	—	—	—	—	x	—
Holopella mira Winchell.....	—	—	—	—	x	—	—	—
Murchisonia quadricincta Winchell.....	—	—	—	x	—	—	—	—
Platyceras sp.....	—	—	—	—	—	—	x	—
<i>Pteropods</i>								
Conularia byblis White.....	—	—	—	x	—	—	—	—
Conularia sp.....	—	—	x	—	—	—	—	—
<i>Scaphopod</i>								
Dentalium grandaevum Winchell.....	x	—	—	x	—	—	x	—
<i>Cephalopods</i>								
Orthoceras indianense Hall.....	x	—	—	x	—	—	x	x
Orthoceras sp. 1.....	—	—	—	—	x	—	—	—
Orthoceras sp. 2.....	—	—	—	—	—	—	x	—
Dawsonoceras heterocinctum (Winchell).....	x	—	—	x	—	—	—	—
Dawsonoceras whitei (Winchell).....	—	—	—	x	—	—	—	—
Gomphoceras sp.....	—	—	x	—	—	—	—	—
Cyrtoceras unicomne Winchell.....	—	—	—	x	—	—	—	—
Phragmoceras expansum Winchell.....	—	—	—	x	—	—	—	—
Gyroceras burlingtonense (Owen).....	—	—	—	—	—	—	—	x
Agoniatites opimus (W. & W.).....	—	—	—	x	—	—	—	—
Goniatile gen. et sp.....	x	—	—	—	—	—	—	—
Ammonoid gen. et sp.....	—	—	—	—	—	—	x	—

FAUNAL TABLE I—Continued.

Beds	Kinderhook		Burlington					
	2	3	1	2	3	4	5	6
<i>Crustaceans</i>								
Brachymetopus sp.	x	—	—	—	—	—	—	—
Griffithides ? sp. 1.	—	—	—	—	x	—	—	—
Griffithides sp. 2.	—	—	—	—	—	—	—	x
Proetus ? sp.	—	—	—	—	—	—	—	x
Palaeopalaemon iowensis Walter ²	—	—	x	—	—	—	—	—
<i>Fishes³</i>								
Pristicladodus springeri St. J. & W.	—	—	x	—	—	—	x	—
Pristicladodus springeri var. armatus St. J. & W.	—	—	x	—	—	—	x	—
Cladodus alternatus St. J. & W.	—	—	x	—	—	—	x	—
Cladodus exiguus St. J. & W.	—	—	x	—	—	—	—	—
Cladodus exilis St. J. & W.	—	—	x	—	—	—	x	—
Cladodus succinctus St. J. & W.	—	—	—	—	—	—	x	—
Cladodus wachsmuthi St. J. & W.	—	—	—	—	—	—	x	—
Thrinacodus nanus St. J. & W.	—	—	—	—	—	—	x	—
Mesodmodus exsculptus St. J. & W.	—	—	x	—	—	—	x	—
Mesodmodus explanatus St. J. & W.	—	—	x	—	—	—	—	—
Orodus daedalus St. J. & W.	—	—	x	—	—	—	—	—
Orodus decussatus St. J. & W.	—	—	x	—	—	—	—	—
Pristodus ? acuminatus St. J. & W.	—	—	x	—	—	—	—	—
Psephodus reticulatus St. J. & W.	—	—	x	—	—	—	x	—
Coelacanthus welleri Eastman.	—	—	x	—	—	—	—	—
Ctenacanthus sculptus St. J. & W.	—	—	x	—	—	—	—	—
Ctenacanthus speciosus St. J. & W.	—	—	x	—	—	—	—	—
Ctenacanthus varians St. J. & W.	—	—	—	—	—	—	x	—
Acondylacanthus gracilis St. J. & W.	—	—	x	—	—	—	x	—
Asteroptychius vetustus St. J. & W.	—	—	x	—	—	—	—	—
Physonemus carinatus St. J. & W.	—	—	—	—	—	—	x	—
Physonemus depressus St. J. & W.	—	—	x	—	—	—	—	—
Physonemus proclivus St. J. & W.	—	—	x	—	—	—	—	—
Venustodus ? sp.	—	—	—	—	—	—	x	—
Chomatodus ? sp.	—	—	—	—	—	—	x	—
Tamaodus ? sp.	—	—	—	—	—	—	x	—
Petalorhynchus sp.	—	—	—	—	—	—	x	—

¹The faunal list and descriptions of the Chonopectus sandstone fossils by Dr. Weller were mainly based on material collected by C. A. White, forming the White Collection at the University of Michigan. Subsequent to publishing his paper (Fauna of the Chonopectus sandstone), Dr. Weller visited the Burlington sections and made large collections from this zone and the higher beds. These collections have been studied by the writer, additional species recognized being included with the previously published lists. Collections made by F. M. Van Tuyl (Stratigraphy of the Mississippian formations of Iowa, Ia. Geo. Survey, Vol. 30, 1925), include some species, according to his identifications not contained in the revised Weller lists. These species are included in the present table with the designation (*).

²Walter, Otto, "Notes on a decapod crustacean from the Kinderhook shale at Burlington, Ia.," Proc. Ia. Acad. Sci., Vol. 24, 119-123 (1917).

³The lower fish fossil horizon at Burlington is in the bluish clay near the top of Bed 1 (Letter from Frank Springer to Stuart Weller, May 12, 1916). Collections were made by Springer on Flint River at lower end of exposure below Starr's Cave, and at Burlington.

THE NORTHEASTERN MISSOURI KINDERHOOK

INTRODUCTION

The Kinderhook strata of northeastern Missouri, including contiguous areas in Iowa and Illinois, possess many features which differentiate them to a greater or less extent from the beds of similar age in other parts of the state. The type sections of the Kinderhook occur in this region, so that its study forms a fitting introduction to the consideration of the group in other districts.

Areal distribution and thickness. Excellent exposures of the lower Mississippian are observed for a distance of nearly seventy miles in the high bluffs of Mississippi River in Missouri and Illinois, and in the tributary streams. In some cases vertical sections from the Ordovician or the Silurian to the upper Osage group of the Mississippian are obtained in a single outcrop. The maximum thickness of exposed Kinderhook strata in the northeast Missouri region is about 225 feet.

Lithologic character. The Kinderhook of northeastern Missouri is diverse in lithologic types. The lowermost formation that appears referable to the Kinderhook is a black, fissile carbonaceous shale. This is overlain by a blue, even-textured, argillaceous shale, which in turn is followed by exceedingly dense, compact, lithographic limestone. A widespread clastic formation consisting of arenaceous shale and very fine-grained sandstone occupies the upper part of the Kinderhook section over a large area but in the northern and southeastern parts of the district a fine-grained drab limestone, or a medium-grained crystalline limestone is found at the top of the Kinderhook. The shale and sandstone surpass in quantity the limestone.

Structure. The Kinderhook of northeastern Missouri has a gentle dip to the north away from the Ozark highland. At Quincy, Illinois, the top of the Kinderhook is found at the level of Mississippi River, but southward the beds rise in the river bluffs until at Hannibal nearly the entire thickness of the group is exposed, and at Louisiana the base of the Kinderhook is nearly 100 feet above the 5 Mississippi. The Kinderhook reappears in southeastern Iowa on the north side of the broad, shallow syncline which occupies the northeastern counties of

Missouri. A detailed study of the structure of the region has recently been published by Krey.²⁷

Divisions. The Kinderhook of northeastern Missouri includes the following formations:

Chouteau limestone

Hannibal formation

Louisiana limestone

Saverton shale

Grassy Creek shale

The Grassy Creek shale was formerly designated simply as the "Black shale." Keyes²⁴ has suggested the name now applied to the formation from its typical development on the headwaters of Grassy Creek, Pike county, Missouri.

The blue or green Saverton shale was also named by Keyes,²⁶ from exposures in the vicinity of Saverton, Ralls county, about seven miles south of Hannibal.

The Louisiana limestone was defined by Keyes²² in 1892. It had been previously known as the Lithographic limestone, on account of the peculiarly even textured, fine-grained character of the rock. It constitutes an easily recognized formation excellently exposed at its type locality, Louisiana, Missouri.

Keyes²² applied the name Hannibal formation to the sandstone and shale overlying the Louisiana limestone, on account of the typical outcrops of these beds at Hannibal. Swallow⁵¹ had called the formation the "Vermicular sandstone and shale" on account of the peculiar, characteristic worm borings in the soft sandstone of the upper part.

The Chouteau limestone was named by Swallow⁵¹ from Chouteau Springs, Cooper county, in central Missouri. He included in the formation two distinct members, a lower dark drab, compact, brittle, thin-bedded limestone and an upper bluish or buff, silico-magnesian, massive limestone. The lower division, to which it seems desirable to restrict the name Chouteau, appears only locally in northeast Missouri.

Unconformity at base of the Kinderhook. Though the Kinderhook, as defined by Meek and Worthen is referred without question to the Mississippian, the exact position of its lower boundary has been unsettled. Study of the sections in northeastern Missouri and western Illinois which show the formations underlying the Kinderhook, calls attention to an important unconformity that appears to mark the base of the Mississippian

deposits. The black Grassy Creek shale is observed in different places to rest upon the Callaway, Mineola, and Cooper limestones of the Devonian, the Edgewood and Sexton Creek formations of the Silurian and the Kimmswick and Plattin limestones of the Ordovician. The areal relations of these formations in part are well shown by Branson.^{4a} In southern Calhoun county, Illinois, and other places where the Grassy Creek shale disappears, younger Kinderhook strata overlie the Devonian or older rocks.

GRASSY CREEK SHALE

Beneath the Louisiana limestone at Louisiana is found about 6 feet of clay shale, the upper 2 feet bluish or greenish in color, the lower 4 feet black and fissile. Northwest of Louisiana both of these divisions become notably thicker and are well exposed at a number of places. The lower black shale division is best exposed along the headwaters of Grassy creek west of Louisiana and has been termed from this place the Grassy Creek shale.

Distribution and thickness. So far as known, the distribution of the Grassy Creek shale is restricted to northeastern Missouri, and the adjacent portion of western Illinois. It reaches its maximum observed thickness, about 45 feet, at its type locality in central Pike county, Missouri.^{37a} Ten miles southeast of Louisiana, at Clarksville, it is 2 to 3 feet thick and shows in some places a thin band of yellow sandy material at its base, above the Edgewood (Silurian) limestone. The formation was not found by the writer farther south in Missouri although Branson^{4a} records its presence south and west of Foley, in Lincoln county. In Pike and Calhoun counties, Illinois, the black shale is excellently exposed in the lower portion of a number of streams flowing into Mississippi River. It has an exposed thickness up to 20 feet but southward it disappears.

Lithologic character. The Grassy Creek shale is a very black to rusty brown, carbonaceous shale. It is hard and fissile, weathering in small, thin, rather flaky fragments. Locally it contains numerous small concretions of iron pyrite, and more or less sandy material is in some places observed near the base. It strongly resembles the Chattanooga black shale.

Paleontologic character. The Grassy Creek shale is practically devoid of organic remains. A 1-inch layer of siliceous limestone is found at the very bottom of the formation at Louisiana which, according to Rowley,³⁷ contains fish teeth, bones, coprolites, and

a small, elongate linguloid shell. A few scattered shells are found elsewhere in the formation, as on Grassy creek where Rowley found a number of specimens of *Lingula* and a small shell resembling *Stropheodonta*. The character of the fish remains is not indicated, and no specific identification of the fish teeth has been made. The Lingulas, which as a group appear to flourish wherever environmental conditions are favorable, are such as abound in almost all deposits of black shale. There is very little specific distinction between species of widely different geologic age, so that as horizon markers they are at best of somewhat indeterminate value. The shell which Rowley identified as *Stropheodonta* may belong to any of a number of related strophomenids and can hardly be regarded as having diagnostic value. Perhaps of negative significance is the absence from the fauna of the distinctive Carboniferous elements which in most localities is well defined even at the base of the Kinderhook.

Correlation. In the absence of satisfactory faunal evidence, conclusions as to the age of the Grassy Creek shale must rest largely on its lithologic character and its stratigraphic relations to associated formations. In lithologic character the Grassy Creek shale suggests of the Upper Devonian "black shale" of the eastern Mississippi valley basin. Ulrich⁵⁶, ⁵⁷ and Bassler² have presented reasons for the belief that at least a part of the so-called Devonian shale is lower Mississippian in age. The Devonian (New Albany) black shale is extensively developed in Ohio, Indiana, eastern Illinois and Kentucky; the Mississippian (Chattanooga) shale is typically exposed in Tennessee and adjoining states and includes the black shale on the south flank of the Ozarks in northern Arkansas and southwestern Missouri.

The formation of black shale deposits seems to depend on conditions which will permit the accumulation of a sufficiently large proportion of carbonaceous material to color the sediments effectively as they are deposited. These conditions have been variously explained by different authors. Whatever the manner in which the shale is made black, it is very possible that the sea in which it accumulated failed to reach some regions until long after it had occupied other areas. It is improbable, for example, that all the deposits referred to the New Albany or the Chattanooga black shales are contemporaneous. Accordingly the Grassy Creek shale of northeast Missouri may correspond to one of the black shale formations farther east, either more or less nearly contemporaneous with it or related to it only as a portion

of the same transgressive advance of the sea over the land. Or while partly equivalent in time with one of the black shales it may be stratigraphically and genetically related to neither. Since black shale deposits probably represent a certain set of physical conditions, the presence of these conditions in one region is not necessarily coincident with their appearance in another.

The Grassy Creek shale rests with marked unconformity on strata of Ordovician, Silurian and Devonian age and appears to be closely related to the overlying largely clastic Kinderhook beds. No evidence of disconformity between the Grassy Creek and the Saverton shale was observed by the writer, and the area of distribution of the Grassy Creek is approximately the same as that of the higher formations. Since this formation appears to be an initial deposit of a sea which remained in the region with only slight changes throughout a large part of Kinderhook time, it seems best to include it with the Kinderhook. It is possibly equivalent to a portion of the Chattanooga.

In Muscatine county, eastern Iowa, there is a deposit of dark, greenish, shale and clayey magnesian limestone with maximum known thickness of 48 feet; it is unconformably separated from Devonian limestone below and Pennsylvanian sandstone above. This shale designated by Udden⁵³, ⁵⁴ the Sweetland Creek shale, contains several *Lingulas*, an unidentified gastropod, two species of phyllocarid crustaceans, and some fish teeth including *Ptyctodus calceolus*. Evidence concerning the age and correlation of the shale is very unsatisfactory, but it probably belongs to the lower Kinderhook. If such is the case it corresponds approximately to the Grassy Creek and Saverton shales of northeastern Missouri. Krey²⁷ classes together all of the shale between the Louisiana limestone and the pre-Kinderhook unconformity designating it "Grassy Creek (Sweetland Creek) shale."

The Chattanooga (?) shale of southeastern Missouri is reported to occur above a *Ptyctodus*-bearing sandstone (Bushberg). In relative position and lithologic character this black shale and greenish or brown sandstone closely correspond to the Chattanooga shale and Sylamore sandstone of southwestern Missouri and northern Arkansas. The Bushberg overlies with apparent conformity the fossiliferous Glen Park limestone, which in western Illinois rests unconformably on the Louisiana limestone. Therefore the Grassy Creek shale beneath the Louis-

iana does not correspond to the Chattanooga (?) of southeast Missouri. It is probably equivalent to the Chattanooga of southwest Missouri and north Arkansas, and the Sweetland Creek shale.

SAVERTON SHALE

The blue shale, termed Saverton, that lies next beneath the Louisiana limestone in northeastern Missouri, is distinct in its lithologic characters from the fissile, black Grassy Creek shale. Except where it occurs in contact with the Hannibal, this shale appears to be recognizable throughout the region of its outcrop. However, Branson⁴ and Krey²⁷ in recent publications have classed all of the shale beneath the Louisiana as Grassy Creek.

Distribution and thickness. The Saverton has about the same areal and stratigraphic relations as the underlying black shale, but it extends farther to the south and probably much farther to the north than that formation. The Saverton crops out somewhat extensively in Marion county, but it is known in the more northerly counties of Missouri only from the more or less doubtful records of well borings. In Ralls county, where the type locality is located the formation attains its maximum observed thickness, about 100 feet. Here the shale is well exposed in the bluffs of Mississippi River and along the tributary streams. With decreased thickness the blue shale continues through Pike county and may be present in Lincoln county. On the east side of Mississippi River, the Saverton is well developed throughout western Pike and Calhoun counties as shown by observations in the river bluffs and along the various streams some miles to the east.

Lithologic character. The color of the formation is, characteristically, a light blue, but not uncommonly it is a bluish green or brown. It is a fairly uniform, soft, argillaceous or sandy shale which on weathering breaks up into small, irregularly shaped fragments. In places it contains thin beds of rather soft, bluish limestone, and may be represented locally by soft massive sandstone. This arenaceous facies is not ordinarily sufficient to hinder the use of the formation for the manufacture of Portland cement. At Ilasco, Ralls county, between Saverton and Hannibal, the formation is extensively mined by the Atlas Portland Cement Company.

Stratigraphy. At Louisiana the Saverton has a thickness varying from $1\frac{1}{2}$ to 2 feet (section 5, p. 71) and at Clarksville

from 1 to $1\frac{1}{2}$ feet (section 6) but to the northwest it is much thicker. In Pike county, Missouri, it attains a maximum thickness according to Buehler^{9a} of 30 feet, but it is not, on an average, more than 10 feet. On Grassy creek it is reported to have a thickness of 18 feet.^{37a} In Ralls county the Saverton has a thickness ranging from 50 to nearly 100 feet.^{9b} West of the station at Saverton the shale is 80 feet thick, and at Ilasco, three miles farther north, it is 60 feet. The Saverton is not exposed at Hannibal, but in central Marion county, it is brought to the surface along the south fork of North river. The most extensive outcrop occurs in the vicinity of Warren, the beds being exposed for nearly four miles along the river south of this point (T. 57 N., Rs. 6-7 W.). Section 3 measured on South Fork about $1\frac{1}{2}$ miles south of its junction with North Fork shows 35 feet of blue shale beneath Louisiana limestone. Farther north the Kinderhook beds disappear from view owing to the northward dip of the strata, but the Saverton shale probably continues a considerable distance beneath the surface, for thick blue shale is recorded in several well borings.

On the east side of Mississippi River the Saverton shale is exposed in Pike and Calhoun counties, Illinois, being readily distinguished where it underlies the Louisiana limestone but it is not certainly identified where the absence of the limestone brings the shale into contact with the Hannibal. Toward the south the Saverton decreases in thickness to less than one foot and finally disappears.

Paleontologic character. The fauna of the Saverton shale is much more abundant and better known than that of the subjacent Grassy Creek shale. Knowledge of the fauna is largely the result of a number of years collecting by Mr. R. R. Rowley, of Louisiana, and the species reported³⁷ are chiefly from that place and nearby localities in Pike county. In the following list, species which occur also in the thin seam of sandy, yellow shale which separates the Saverton from the Louisiana limestone, are indicated by (x), and those which occur in the Louisiana limestone by (L).

Faunal Table II—Fauna of the Saverton Shale

*Sponge ?**Ptychostylus subtumidus* Gurley*Corals*

Zaphrentis acuta W. & W. ? (x)
Zaphrentis parasitica Rowley (x, L)
Zaphrentis palmeri Worthen (x)
Palaeacis enormis (M. & W.) (x, L)
Conopterium effusum Winchell (x, L)

Worms

Spirorbis kinderhookensis Gurley (x, L)
Cornulites carbonarius Gurley (x, L)

*Crinoid**Platycrinus dodgei* Rowley (x, L)*Brachiopods*

Orbiculoidea limata Rowley (x)
Crania dodgei Rowley (x, L)
Crania rowleyi Gurley (x, L)
Schuchertella lens (White) (x, L)
Chonetes geniculatus White (x, L)
Chonetes ornatus Shumard (x, L)
Productella pyxidata (Hall) (x, L)
Rhipidomella missouriensis (Swallow) (x, L)
Rhynchopora ? rowleyi Weller (x, L)
Cyrtina acutirostris (Shumard) (x, L)
Delthyris clarksvillensis (Winchell) (x, L)
Spirifer marionensis Shumard (x, L)
Syringothyris hannibalensis Swallow ? (x, L)

Nucleospira rowleyi Weller (x, L)
Athyris hannibalensis Swallow (x, L)

Pelecypods

Grammysia hannibalensis Shumard (x, L)
Aviculopecten ? marbuti Rowley (x, L)
Pelecypod gen. and sp.

Gastropods

Pleurotomaria ? sp.
Platyceras pulcherrimum Rowley (x)

*Pteropod**Conularia marionensis* Swallow (x)*Cephalopods*

Orthoceras minimum Rowley (x, L)
Goniatites ? sp. (x, L)

Fishes

Dinichthys rowleyi Branson
Dinichthys missouriensis Branson
Dinichthys sp.
Titanichthys ? sp.
Mylostoma eastmani Branson
Ptyctodus calceolus N. & W.
Conchodus variabilis Eastman
Helodus rowleyi Branson
Helodus devonicus Branson
Helodus incipiens Branson
Helodus clivulus Branson
Eoorodus typus Branson
Psephodus sp.
Dipterus mordax Eastman

Most of the invertebrate fossils from the Saverton are recorded also in the Louisiana limestone. Associated with these invertebrates is a large and important fish fauna which has been described by Branson.⁵ Since the invertebrates of the Saverton are essentially identical with those of the Louisiana, they are as indicative of Mississippian age as is that fauna. The character of the fish fauna and its significance in the correlation of the formation are discussed briefly in the succeeding section.

Correlation. Of the 32 invertebrate species in the Saverton fauna, all but seven are found in the Louisiana limestone. This large number of species which are common to both formations includes some of the most abundant and characteristic Louisiana

forms, such as *Schuchertella lens*, *Chonetes ornatus*, *Productella pyxidata*, *Rhipidomella missouriensis*, *Cyrtina acutirostris*, *Spirifer marionensis*, *Syringothyris hannibalensis* and *Athyris hannibalensis*. The Saverton fauna is but a slight modification of the Louisiana limestone fauna.

Between the Saverton shale and the Louisiana limestone in the section at Louisiana, there is a thin seam of very fossiliferous sandy shale 1 to 5 inches in thickness. On lithologic grounds this shale is naturally referred to the subjacent formation, but since it is also identical with the thin, fossiliferous sandy partings between the lower layers of the overlying limestone, it has generally been included with the Louisiana. All of the Saverton fauna except the fishes, the peculiar and problematic *Ptychostylus subtumidus*, and a small, unidentified gastropod, is to be found in the sandy yellow shale, ten of the species which are doubtfully recognized in the Saverton being positively identified here. In addition there are fifteen species belonging to the Louisiana but not found in the Saverton, which occur in the yellow shale. At this intermediate horizon there is to be found, therefore, practically the entire invertebrate fauna of the Saverton shale including the species not found in the Louisiana limestone, and almost the complete fauna of the Louisiana, including a number of species not represented in the Saverton fauna. Further, there is no indication of any physical break, and in places where the yellow intermediate shale is especially thin, Rowley^{5a} has observed the continuation downward of the yellow shale fossils into the fish-bone horizon of the Saverton. The geographic distribution of the Louisiana and Saverton are similar, and faunal and physical evidence indicates that the shale is assignable to the Mississippian.

Interesting paleontologic evidence concerning the age of the Saverton shale is found in its fish fauna. This includes on the one hand such genera as *Dinichthys*, *Ptyctodus* and *Conchodus*, which have been regarded generally as diagnostic of the Devonian, but on the other, a number of highly characteristic Mississippian genera, *Helodus*, *Psephodus* and *Eoorodus*, a new genus which is practically equivalent to the common *Orodus* of the Chouteau and other Kinderhook formations. At the outset the fauna appears to be somewhat composite in its nature.

Among the arthrodires, which are possibly most suggestive of the Devonian, are two species of *Dinichthys*, one of *Mylostoma*,

and a rather doubtful form referred to *Titanichthys* ? sp. According to Branson both species of *Dinichthys* are so closely related to *D. intermedius* of the Cleveland shale in Ohio, that they are distinguished by minor features only. It is possible that they were rather closely contemporaneous. The Cleveland shale is classed by Ulrich as Mississippian, but if it is actually late Devonian *Dinichthys* may have lived in early Mississippian seas as well.

The teeth of *Ptyctodus calceolus*, which are rather numerous in the Saverton shale, are common elsewhere in beds classed as Devonian and Kinderhook in age. They are, perhaps, the most abundant of all the fish remains of the Iowa Devonian, occurring especially in the State quarry beds of Johnson county. In Callaway County, Missouri, they are found with another species of *Ptyctodus* in the Snyder creek shale of the Devonian age.⁵ In addition to its characteristic occurrence in the Devonian, the teeth are abundant at the base of the Sweetland Creek shale in Iowa^{70a} which is possibly of early Mississippian age, and in a more or less water-worn condition are very common in the Sylamore sandstone of the Kinderhook in central and southwestern Missouri. Branson^{5b} has suggested that the more or less water-worn *Ptyctodus* teeth found in beds of undoubted Kinderhook age have been derived by erosion from Devonian beds in which they originally occurred. This is no doubt true in certain cases, although the teeth found in the Devonian shales are also generally rounded and worn, but Weller⁶⁸ has found complete and unworn *Ptyctodus* teeth in the Glen Park limestone of southeastern Missouri, a formation younger than the Saverton. The occurrence of *Ptyctodus* teeth in the Saverton shale is not satisfactory evidence of Devonian age for the formation.

One tooth from the fish fauna of the Saverton has been identified by Charles Eastman with his species *Conchodus variabilis* which is only known elsewhere in the upper Devonian State Quarry beds of Johnson County, Iowa. That it occurs in the Saverton at all shows that the species has a longer range than had hitherto been assigned to it, but whether this range extends into the Mississippian or is still restricted to the Devonian depends on the age of the Saverton shale.

The pavement toothed sharks which appear in association with these genera of more or less pronounced Devonian aspect, are characteristic of the Mississippian. There are six species of these sharks in the Saverton fauna, four belonging to the

genus *Helodus*, one to *Psephodus* and another which is closely related to *Orodus*. The *Helodus* teeth of the Saverton shale are so similar to specimens from the Chouteau limestone at Sedalia and Providence, Missouri, they are only distinguished by minute details.⁵ *Eorodus* is very like the abundant *Orodus* of the Chouteau. The genus *Psephodus* is represented by a rather imperfect tooth in the Saverton fauna which is most similar to *P. obliquus* from the Kinderhook of southeastern Iowa.

Study of this fish fauna emphasizes its transitional, intermediate character between the recognized upper Devonian faunas and those of known Kinderhook age. The arthrodires have been regarded as most strongly suggestive of the Devonian, but their significance depends largely on the determination of the age of the black shales of Ohio and Tennessee in which they characteristically occur; so-called Devonian fishes may have persisted into the Mississippian period. The sharks of the Saverton fauna are related to the Mississippian. They are forerunners of the group which attained such a remarkable deployment and predominance in the seas of later Mississippian time.

In the yellow clay shale at the top of the Saverton or base of the Louisiana, R. S. Bassler* has found the distinctive ostracod *Ctenobolbina loculata* Ulrich, which is a characteristic fossil of the Ridgetop shale of Tennessee that occurs next above the Chattanooga black shale of that region. This occurrence suggests the time equivalence of the Saverton shale and the Ridgetop shale.

LOUISIANA LIMESTONE

The Louisiana limestone is a peculiarly distinctive portion of the Kinderhook group in northeastern Missouri. Not only does it possess almost unmistakable lithologic characters but its fauna differs materially from that of higher beds in the Mississippian. Its typical features are persistent throughout the region in which it is observed.

Distribution and thickness. The Louisiana is apparently limited to northeastern Missouri and the adjoining part of Illinois. Even within this district it is rather local in its development. It extends northward as far as central Marion county where the Kinderhook disappears beneath the surface. Outcrops are numerous in Marion, Ralls, and Pike counties, the best

*Personal communication.



A. Weathered exposure of Louisiana limestone on Bear Creek, south of Hannibal, Marion County.



B. Upper Burlington limestone. The projecting crag at the top of Lovers Leap, Hannibal, looking down on the Mississippi River.

exposures occurring in the bluffs of Mississippi River and its tributaries. The sections at Louisiana, Hannibal and Clarksville are excellent and characteristic. South of Clarksville the Louisiana limestone has not been observed, but on the east side of Mississippi River in Calhoun county, Illinois, it extends southeast nearly to the Cap au Gres fault at the mouth of Illinois river.

The average thickness of the Louisiana limestone in Missouri is 35 or 40 feet. The maximum observed thickness of the formation is 67 feet 7 inches, measured near Ilasco, Ralls county. In Illinois, the Louisiana is very thin, averaging not more than 3 or 4 feet and decreasing to almost nothing in its outcrops farthest south. The Louisiana is an elongate, lenticular body, with its longer axis subparallel to Mississippi river. In an east-west direction it thins very rapidly but along the Mississippi it declines gradually from its maximum thickness.

Lithologic character. As suggested by the name (Lithographic) first given to this formation by Swallow⁵¹ and other early geologists, the texture of the Louisiana limestone is very similar to the compact, fine and evenly grained, homogeneous rocks used for lithographic printing. It is hard but brittle and under the blow of the hammer breaks with sharply conchoidal fracture into angular fragments. The formation is typically grayish or bluish drab in color, in some cases light brownish to buff. It is commonly lighter and has a more reddish or violet cast than the lithologically somewhat similar compact, bluish drab Chouteau limestone of central Missouri.

The Louisiana shows in part a high content of lime carbonate, indicating a fairly pure limestone. Study of the exposures both at Louisiana and at Hannibal indicate, however, that a considerable part of the formation has been dolomitized. In this change the limestone becomes coarser in texture and more granular, its color changes to yellowish or buff and its fracture is subconchoidal. Dolomitization appears to have proceeded along bedding planes and to some extent along joints, only partially altering the formation. The dolomitized rock is not so readily attacked by weathering as the unaltered limestone. The exposed surface, therefore, has a distinctly uneven and mottled appearance.

The bedding is quite regular and characteristic throughout; individual beds have a thickness of 4 to 9 inches in the lower part of the formation. The beds are notably thinner toward the

top where the average thickness is 1 to 2½ inches. At Hannibal, the Louisiana is capped by a massive layer ranging in thickness from 1 to 2 feet.

Scattered irregularly, especially through the lower layers of the formation, are calcite geodes variable in shape and size, completely or only partially filled with milky or transparent calcite, which is coarsely crystalline. The usual observed diameter of these calcite fillings range from 1 to about 5 inches.

Stratigraphy. In Marion county the Louisiana limestone is exposed extensively along the south fork of North river and various tributaries in the vicinity of Hannibal on Bear creek, and in the Mississippi river bluffs above and below Hannibal. From a point on the south fork of North river, about two miles south of Warren where 20 feet of the Louisiana is exposed, the formation crops out more or less frequently nearly to the junction with the north fork where Section 3 is reported by Buehler.⁹⁰

In the bluffs north of Hannibal the Louisiana has an exposed thickness of 50 to 55 feet, but this does not include the entire formation. At Lovers Leap below Hannibal a complete but partially obscured section from the middle of the Louisiana to the Upper Burlington appears (Section 4). The Louisiana occupies the lower part of the Mississippi river bluff south of Hannibal, being exposed at various points as far south as Clarksville. The complete thickness of the Louisiana at Ilasco, Ralls county, is 67 feet 7 inches. At Louisiana the limestone has a thickness of 50 feet and is well exposed at a number of places in and near the town. At Clarksville, ten miles southeast of Louisiana, there are a number of quarries in the limestone.

West of Mississippi river the Louisiana limestone thins with surprising rapidity. On the head waters of Noix creek, near Bowling Green, less than 12 miles from Clarksville and Louisiana, the formation is apparently missing. Overlying the Edgewood (Alexandrian) limestone are the black and greenish blue shales of the Grassy Creek and Saverton formations. The shales are exposed practically continuously from the large quarry in the Bowling Green northeast of town to the quarries in the Sedalia (?) and Burlington limestones, upstream a distance of about one-half mile (Section 7). According to Rowley³⁷⁰ the Louisiana limestone is observed with a thickness of 8 feet on Noix creek two miles from Bowling Green. Near Elk Lick postoffice in the northwestern corner of Pike county, sec. 13, T. 54 N., R. 55 W.,

its thickness is less than 2 feet. The westward thinning and disappearance of the Louisiana is also indicated by well borings in Ralls and in southwest Pike counties.

On the east side of Mississippi river exposures in the bluffs and along the small west-flowing streams are found in Calhoun county but not farther north, though the bluffs on the Illinois side are not more than six or seven miles from those in Missouri which contain the nearly continuous outcrops of Louisiana limestone 30 to 60 feet in thickness. It is possible that the Louisiana is represented by strata in the Kinderhook of Illinois which differ entirely from the typical formation in Missouri, but the sharply lenticular character of the "lithographic" limestone in an east-west direction seems evident. In the vicinity of Hamburg the Louisiana is disconformably overlain by fossiliferous limestone and shale bearing a fauna similar to that of the Glen Park limestone of southeastern Missouri.

Well borings indicate that the Louisiana extends an unknown distance northward. It has a reported thickness of 50 feet at Canton, Missouri, and 62 feet at Warsaw, Illinois, 30 and 46 miles respectively, north of Hannibal. It is not found at Kahoka, Mo., 16 miles west of Warsaw, nor at Ft. Madison, Iowa, the same distance northward.

Paleontologic character. Fossils in the Louisiana limestone are most abundant in the lowermost few feet of the formation. A thin seam of yellowish sandy shale at the base of the limestone, averaging not more than 3 or 4 inches in thickness, contains a large number of species. This shale has commonly been included with the Louisiana limestone. In a study of the distribution of the Louisiana fauna within the formation at Louisiana, Keyes and Rowley²⁵ distinguished four zones, as follows:

Faunal Zones in the Louisiana Limestone at Louisiana

	Thickness	
	Feet.	Inches.
Louisiana limestone		
4. Limestone, buff to gray, compact, very fine-grained, in layers 4 to 6 inches thick "lithographic" in texture.....	34	
3. Limestone, similar to above.....	8	
2. Limestone, similar to above, layers thicker, separated by buff, sandy partings.....	6	
1. Shale, buff, sandy.....		2-6

The fauna includes more than fifty identified species, which are distributed in the zones of the foregoing section as shown in Faunal Table III.

Faunal Table III.—Fauna of the Louisiana Limestone

	Louisiana, Mo., Zones				Ham- burg, Ill.	Hardin, Ill.
	1	2	3	4		
<i>Corals</i>						
<i>Zaphrentis acuta</i> W. & W.	x	x	x	—	—	—
<i>Zaphrentis palmeri</i> Rowley.	x	—	—	—	x	?
<i>Zaphrentis parasitica</i> (Worthen).	x	x	—	—	—	—
<i>Zaphrentis</i> sp.	—	—	—	—	—	x
<i>Palaeacis enormis</i> M. & W.	x	x	—	—	—	—
<i>Conopterium effusum</i> Winchell.	x	—	—	—	—	—
<i>Worms</i>						
<i>Spirorbis kinderhookensis</i> Gurley.	x	x	—	—	—	—
<i>Cornulites carbonarius</i> Gurley.	x	x	—	—	—	—
<i>Crinoids</i>						
<i>Platycrinus dodgei</i> Rowley.	x	x	—	—	—	—
<i>Allagecrinus americanus</i> Rowley.	?	x	—	—	—	—
<i>Poteriocrinus jeffriesi</i> Rowley.	?	x	—	—	—	—
<i>Bryozoans</i>						
<i>Tabulipora</i> sp. 1.	x	x	—	—	—	—
<i>Tabulipora</i> sp. 2.	x	x	—	—	—	—
<i>Leioclema</i> sp.	x	x	—	—	—	—
<i>Streblotrypa</i> ? sp.	x	x	—	—	—	—
<i>Brachiopods</i>						
<i>Lingula louisianensis</i> Weller.	—	x	—	—	—	—
<i>Orbiculoidea limata</i> Rowley.	x	—	—	—	—	—
<i>Crania dodgei</i> Rowley.	x	x	—	—	—	x
<i>Crania rowleyi</i> Gurley.	x	x	—	—	—	—
<i>Crania spiculata</i> Rowley.	?	x	—	—	—	—
<i>Schuchertella lens</i> (White).	x	x	—	—	x	x
<i>Chonetes geniculatus</i> White.	x	x	—	—	—	x
<i>Chonetes ornatus</i> Shumard.	x	x	—	—	x	x
<i>Productella pyxidata</i> (Hall).	x	x	x	x	x	x
<i>Strophalosia beecheri</i> Rowley.	x	—	—	—	—	—
<i>Strophalosia scintilla</i> Beecher.	x	x	—	—	—	—
<i>Rhipidomella missouriensis</i> (Swallow).	x	x	—	—	x	x
<i>Rhynchopora</i> ? rowleyi Weller.	x	x	—	—	—	—
<i>Centronella</i> ? louisianensis Weller.	—	x	—	—	—	—
<i>Selenella pediculus</i> (Rowley).	x	—	—	—	—	—
<i>Trigeria</i> ? curriei Rowley.	—	x	—	—	—	—
<i>Dielasma</i> sp.	—	—	—	—	—	x
<i>Cyrtina acutirostris</i> Shumard.	x	x	x	—	x	x
<i>Delthyris clarksvillensis</i> (Winchell).	x	x	x	—	x	x
<i>Spirifer marionensis</i> Shumard.	x	x	—	—	x	x
<i>Spirifer</i> sp.	—	x	—	—	—	—
<i>Syringothyris hannibalensis</i> Swallow.	x	x	x	—	?	x
<i>Acanthospira aciculifera</i> (Rowley).	x	x	—	—	—	—
<i>Ambocoelia minuta</i> White.	x	x	x	—	x	x
<i>Nucleospira rowleyi</i> Weller.	—	x	x	—	—	—

FAUNAL TABLE III—Continued.

	Louisiana, Mo., Zones				Ham- burg, Ill.	Hardin, Ill.
	1	2	3	4		
<i>Brachiopods—Cont'd</i>						
<i>Camarophorella missouriensis</i> (Winchell) ..	x	x	—	—	—	—
<i>Athyris hannibalensis</i> Swallow	x	x	—	—	—	—
<i>Pelecypods</i>						
<i>Grammysia hannibalensis</i> (Shumard)	x	x	—	—	—	—
<i>Aviculopecten ? marbuti</i> Rowley	?	x	—	—	—	—
<i>Gastropods</i>						
<i>Pleurotomaria minima</i> Rowley	—	x	x	—	—	—
<i>Pleurotomaria</i> sp.	—	x	—	—	—	—
<i>Murchisonia ? pygmaea</i> Rowley	—	x	x	—	—	—
<i>Platyceras anomalum</i> Rowley	—	x	—	—	—	—
<i>Platyceras pulcherrimum</i> Rowley	x	—	—	—	—	—
<i>Platyceras</i> sp.	—	—	—	—	—	x
<i>Pteropod</i>						
<i>Conularia marionensis</i> Swallow	x	?	—	—	—	—
<i>Cephalopods</i>						
<i>Orthoceras minimum</i> Rowley	?	x	—	—	—	—
<i>Prolecanites ? louisianensis</i> (Rowley)	?	x	—	—	—	—
<i>Prolecanites</i> sp.	—	x	x	—	—	—
<i>Prolecanites</i> n. sp.	—	—	—	—	x	—
<i>Crustaceans</i>						
<i>Brachymetopus stratton-porteri</i> (Rowley) ..	x	—	—	—	—	—
<i>Proetus missouriensis</i> Shumard	—	x	—	—	—	x
<i>Uncertain sedes</i>						
<i>Filicites gracilis</i> (Shumard)	—	—	x	—	—	—
<i>Leptodiscus corrugatus</i> Rowley	?	x	—	—	—	—

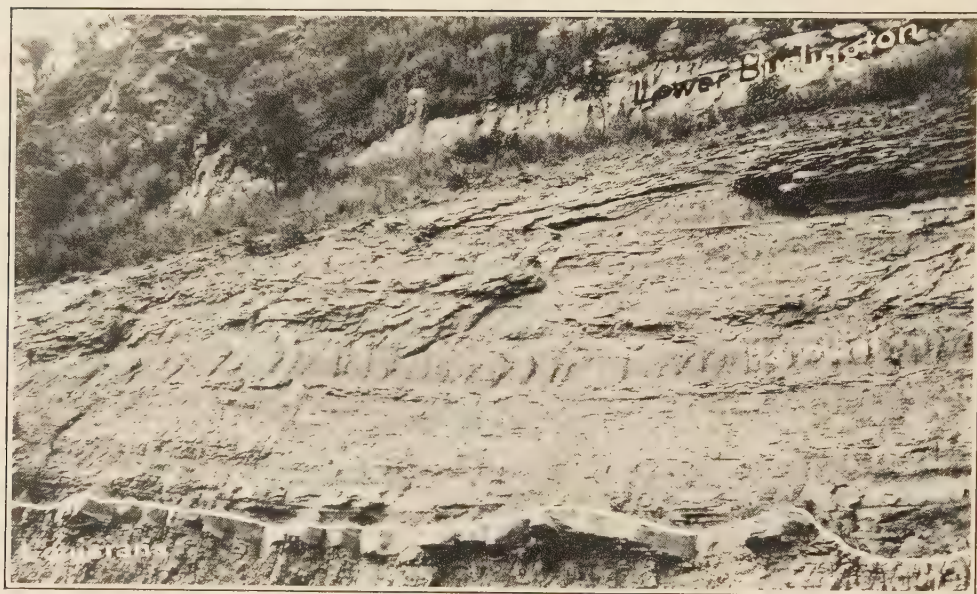
Analysis of the above fauna does not afford wholly satisfactory evidence concerning the age of the formation. Of the species which have been listed, a large number are restricted to the Louisiana limestone and subjacent shale. Of the remainder some are strongly suggestive of the Devonian, others have their closest affinities with the Mississippian.

Of the genera that are represented the larger number is common to both Devonian and Mississippian. The mollusca are long ranging forms, some of which persist through most of the Paleozoic. Among the corals the zaphrentids are suggestive of the Mississippian for they reached their greatest development in that period. *Palaeacis* first appears in the Lower Carboniferous of Scotland and North America. Of the crinoids, *Platy-*

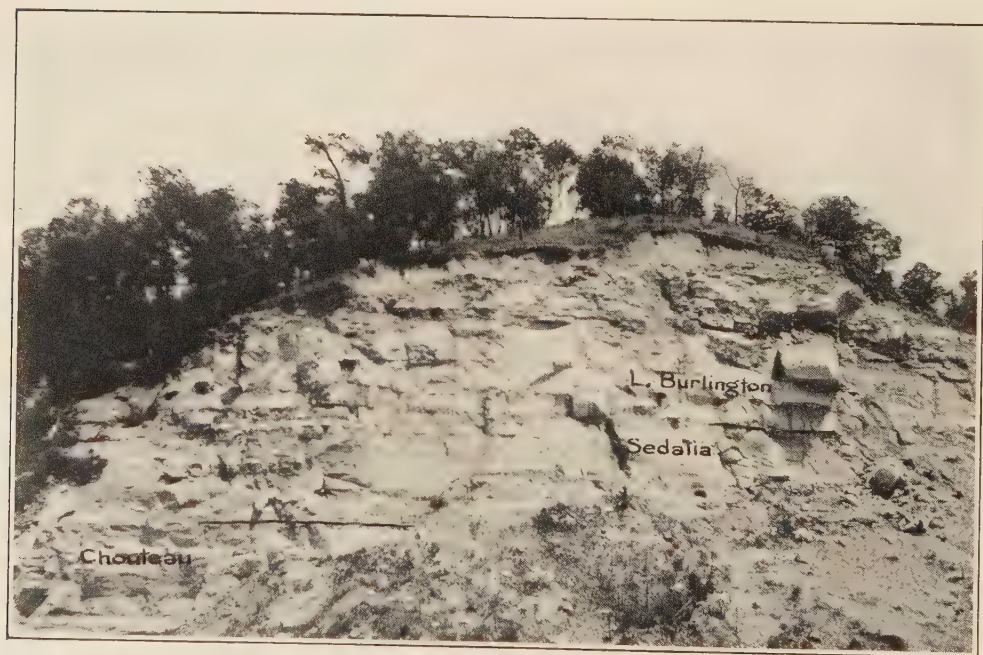
crinus is the most abundant form in the Louisiana limestone. This genus occurs in beds of Devonian age but reaches its maximum and most characteristic development in the Osage epoch of the Mississippian. *Allagecrinus* is not known in the Devonian; it appears first in the Kinderhook beds in North America and at the base of the Lower Carboniferous in Great Britain. Among the bryozoa *Tabulipora* is a Carboniferous form, *Leioclema* and *Streblotrypa* are of ancient stocks. The brachiopods, including 20 genera and 25 species, are the dominant element in the fauna of the Louisiana limestone. Twelve genera are long ranging forms without great significance, but of the remainder some are very strongly suggestive of the Mississippian, some of the Devonian. The genus *Productella*, which is not certainly known elsewhere in the Mississippian, is represented in the Louisiana limestone fauna by *Productella pyxidata*, apparently a true species of this genus. Should it be determined that the numerous *Productella*-like forms such as *P. concentrica* of the Chouteau limestone, are properly placed in this genus, the presence of abundant *Productella* in the Louisiana fauna is not specially suggestive of Devonian age. *Centronella* and *Trigeria*, to which two of the Louisiana species are tentatively referred, are Devonian genera. *Trigeria* is not reported definitely in the Mississippian, but *Centronella* is possibly present in the Burlington limestone. *Cyrtina* and *Delthyris* occur in beds of known Mississippian age, but are most abundant in the Devonian. The genus *Syringothyris*, though reported from beds of undoubted Devonian age,⁴⁰ is one of the most characteristic of the genera of the early Mississippian. Its common occurrence in the fauna of Louisiana with *Camarophorella* and *Rhynchopora* which, so far as known, are only found in the Carboniferous, points to the Mississippian age of the formation. The trilobite *Brachymetopus*, an easily recognized and characteristic Mississippian genus, has the same significance. These faunal elements indicate that the Louisiana is younger than the Devonian.

Fossils collected from the Louisiana limestone at Hamburg, and 3 miles south of Hardin (See Faunal Table III), correspond to those found in Missouri.

Correlation. The most obvious relationship of the Louisiana limestone fauna is with that of the subjacent Saverton shale. Younger Kinderhook strata at least locally, rest with noticeable unconformity on the Louisiana and contain a fauna not closely related to the subjacent limestone. These beds are, therefore,



A. The Hannibal shale at Lovers Leap.



B. Mississippian bluff on Missouri River at Easley, Boone County.

much less closely related to the Louisiana limestone than the Louisiana is to the underlying shale.

Concerning the equivalents of the Louisiana in other districts it is difficult to make definite conclusions. No other formation, so far as present data indicate, has any close faunal similarity to the Louisiana. Indeed, excepting the Saverton, almost every species of the Louisiana limestone is restricted to that formation. It is accordingly necessary to determine the relations of the formation on other grounds.

At Kinderhook, Illinois, and at Burlington, Iowa, there is a bed of bluish drab, "fragmental" limestone (McKerney member) which in lithologic character is suggestive of the Louisiana limestone. These beds have been compared with the Louisiana^{67a} and the suggestion has been made that they may represent the northward and eastward extension of that formation. Unfortunately the bed at Kinderhook is practically barren of fossils. It seems probable, however, that the type specimen of *Paryphorhynchus striatocostatum* came from this horizon, and Weller^{67a} has reported a specimen of *Productella pyxidata* from this limestone at Kinderhook. The "fragmental" limestone at Burlington (Bed 4) occupies a stratigraphic position corresponding to that of the upper limestone at Kinderhook and contains typical specimens of *Paryphorhynchus striatocostatum*. The Burlington bed contains in addition *Chonopectus fischeri*, *Allorhynchus heteropse*, *A. unicum*, *Rhynchopora pustulosa* and *Syringothyris halli*.

Of the fossils which have been named not one is present in the typical Louisiana fauna of Missouri. The stratigraphic position of the Louisiana moreover, appears to be distinctly lower than that of the limestone of the Burlington and Kinderhook sections, for in both cases the latter overlies fossiliferous (English River) sandstone, which as will be pointed out, seems referable to the Hannibal formation. The "fragmental" limestone at Kinderhook is overlain by the Burlington limestone while the Louisiana is separated from the Burlington by more than 100 feet of shale, sandstone and limestone; the limestone at Kinderhook overlies 40 feet of fossiliferous, sandy, magnesian beds which have no equivalent whatever beneath the Louisiana limestone. Accordingly, it seems certain that the Louisiana limestone is not the equivalent of the "fragmental" limestone of Kinderhook and Burlington.

In Calhoun county, Illinois, the Louisiana limestone is found beneath shale and limestone which contain a fauna corresponding to that of the Glen Park limestone of southeastern Missouri. At one place the Glen Park limestone is overlain by a fissile black shale containing minute *Sporangites* similar to those of the Chattanooga and Ohio black shales. If this black shale in southeastern Missouri is the time equivalent of the Chattanooga shale the Louisiana limestone is in part, at least, older.

HANNIBAL FORMATION

Overlying the Louisiana limestone is the clastic Hannibal formation consisting of bluish green sandy shale and soft fine-grained rather massive sandstone.

Distribution and thickness. The Hannibal is practically co-extensive in distribution with the Kinderhook of northeastern Missouri, being exposed from central Marion county to southeastern Pike county, in Missouri, and in Illinois from Pike to Jersey counties. Westward from the Mississippi, the Hannibal formation rapidly becomes thinner. In southwestern Pike county it is represented by only a few feet of shaly sandstone, and in central Missouri along Missouri River it is not observed at all. In thickness the Hannibal varies from a few feet to a maximum of about 100 feet, measured in the vicinity of Clarksville. At Lovers Leap, south of Hannibal, the formation is 67 feet thick.

Lithologic character. The Hannibal formation has fairly uniform, well defined lithologic characters. Perhaps the most typical feature is its content of fine sandy material which varies from an amount almost low enough to permit the use of the shale in the manufacture of Portland cement to one in which the entire rock is composed of minute, rather poorly cemented sand grains. The larger part is a sandy shale. There is no sharp line of division between the shale and the sandstone; in many exposures the beds may be termed almost indifferently sandy shale or shaly sandstone. The shale and sand are cemented by lime carbonate, the calcareous content in the shale increasing locally until the rock becomes a sandy limestone. In certain of the exposures of the Hannibal in Illinois the limy beds are distinctly magnesian.

The color of the formation is characteristically bluish or brownish green, changing locally to a deep olive green or light

brown. Long weathered exposures where the formation has broken down to more or less earthy material show a grayish brown color. As a whole the color in any one exposure or in a single zone appears fairly uniform, but close examination reveals a fine and irregular color mottling in shades of green and brown or drab. This is not, however, a persistent feature.

The sandstone is in most cases massive but rather soft and tends to weather in rounded surfaces. Where weathering is active, the rock tends to break along irregular, obliquely inclined joint planes. The most noteworthy peculiarity of the sandstone is the abundance of irregular tubular markings which on account of their resemblance to the borings of worms suggested the name "Vermicular" which was given to the formation by the early geologists. These markings are almost always present, especially in the upper portion of the sandstone, but at some places, as near Clarksville, they seem to be much more abundant than in others. Another common marking is that of the "cock tail" *Taonurus*, or *Spirophyton*. In the freshly broken rock these features are marked by color and texture but on weathering they are brought into more or less relief. On account of the porous sandy nature of the Hannibal, the fossils which occur are generally preserved as casts, the shell substance having been removed by solution. In the shale, fossils are in most cases pyritized.

For reasons presented in the discussion of correlation the compact, bluish drab limestone (See Section 1, p. 21), which occurs at the top of the Kinderhook section at Kinderhook, Illinois, is regarded as a member (McKerney) of the Hannibal formation. This limestone which is fine-grained and breaks with a sharply conchoidal fracture, is not known in Missouri.

Stratigraphy. In Marion county the Hannibal formation is widespread and fairly uniform in thickness. More or less complete exposures are to be found on most of the streams in the central and southern part of the county, especially on the north and south forks of North river. The most northwestern observed exposure is found on South Fabius river south of Nelsonville, sec. 21-22, T. 59 N., R. 8 W., where 23 feet of the shale and sandstone appear.⁴⁴ In the vicinity of Philadelphia in the west central part of the county, the Hannibal has a thickness of at least 60 feet. On the north fork of North river exposures of 30 to 75 feet of the formation are not infrequent as far east as Palmyra, a short distance from the Mississippi river bluffs. On the south fork there are outcrops of Hannibal from

a point south of Warren to the mouth of the north fork. Throughout the southeastern part of the county on See creek, Lick creek, South river, Bear creek and along Mississippi river as far north as the valley of South river opposite Palmyra, the Hannibal has all the characters and thickness observed at the type locality. The best exposure in the vicinity of Hannibal showing the complete thickness of the formation is found at Lovers Leap, the projecting bluff of the Mississippi just south of Hannibal (Section 4).

Partial exposures of the Hannibal are observed in the bluffs of Mississippi river in Ralls and Pike counties, but at no place, so far as known, is the complete thickness of the formation uncovered. At Louisiana the thickness of the Hannibal is 85 feet (Section 5), the upper 10 feet of which is fossiliferous sandstone. At Clarksville exposures of the Hannibal are good at the north end of Pinnacle Hill, just above the town. Most of the upper part of the formation, measuring at least 35 feet, consists of the soft, abundantly "vermicular" massive sandstone. The total thickness of the Hannibal at this point is 90 feet (Section 6).

In section 7 measured on Noix creek a short distance northeast of Bowling Green, the Hannibal is represented by only 5 feet of massive, greenish brown sandstone, the complete interval from the base of the Sedalia (?) limestone to the top of the Edgewood (Silurian) limestone being not more than 25 feet.

The Hannibal is present on the east side of Mississippi river cropping out in the bluffs and along the streams of Pike and Calhoun counties, Illinois. The general character and thickness of the formation resemble that described in Missouri except that sandy magnesian limestone, bearing fossils, is found at several places. Toward the south near Hamburg, the fossiliferous Glen Park limestone, partly oolitic in texture, appears between the Hannibal and Louisiana.

Paleontologic character. The Hannibal shale and sandstone have been generally regarded as practically unfossiliferous. A few pyritized, more or less unidentifiable fossils locally occur in the shale, but in most places there is no indication of organic remains except *Spirophyton* and the worm borings which Weller has called *Scalgrituba missouriensis*.

In the vicinity of Louisiana the upper sandstone is fossiliferous. The fossils occur as casts which are not always identifiable with certainty, but a much more satisfactory view of the faunal character of the formation is obtainable at this place than

is possible in most other localities. Faunal Table IV shows the nature of faunas of the Hannibal in northeastern Missouri and western Illinois.

Faunal Table IV.—Fauna of the Hannibal Formation in Northeastern Missouri and Western Illinois.¹

Localities		Kinderhook, Ill.	Rockport, Ill.	Pleasant Hill, Ill.	Louisiana, Mo.
<i>Corals</i>					
†	Cyathaxonia tantilla (Miller).....	—	—	x	—
†	Cyathaxonia n. sp.....	—	—	x	—
†	Zaphrentis chouteauensis (Miller).....	—	x	—	—
	Zaphrentis sp.....	—	—	x	—
	Amplexus sp.....	—	—	x	—
	Amplexus sp.....	—	x	—	—
<i>Worm</i>					
° †	Scalarituba missouriensis Weller.....	x	—	—	x
<i>Brachiopods</i>					
	Lingula halli White.....	—	—	—	x
	Orbiculoidea n. sp.....	?	—	—	x
	Schuchertella sp. 1.....	—	—	—	x
	Schuchertella sp. 2.....	—	—	—	x
†	Schellwienella hannibalensis Moore....	x	—	—	x
	Schellwienella sp.....	—	—	—	x
°	Chonetes alatus Moore.....	x	—	—	x
°	Chonetes geniculatus White.....	x	—	x	?
†	Chonetes illinoisensis Worthen.....	x	—	—	—
	Chonetes logani N. & P.....	—	—	—	x
	Chonetes sp.....	—	—	—	x
	Chonetes sp.....	—	x	x	—
	Productella pyxidata (Hall).....	—	—	x	—
°	Productus curtirostris Winchell.....	x	—	—	—
°	Productus mesicostalis Weller.....	x	—	x	—
†	Productus sp. cf. P. arcuatus Hall.....	—	—	x	x
†	Avonia sp. cf. A. blairi (Miller).....	—	—	—	x
° †	Pustula concentrica (Hall).....	?	—	—	x
	Pustula sublaevis (Weller).....	x	—	—	—
	Pustula n. sp.....	—	—	—	x
°	Rhipidomella missouriensis (Swallow)...	—	x	x	x
†	Rhipidomella thiemei (White).....	x	?	x	x
	Schizophoria sp.....	—	x	x	—
	Delthyris sp.....	—	x	x	—
†	Camarotoechia tuta (Miller).....	—	—	—	x
	Camarotoechia sp.....	—	—	—	x
°	Paryphorhynchus transversum Weller..	x	—	—	—
†	Shumardella missouriensis (Shumard)...	—	—	x	—

¹Species present in the English River (Chonopectus) sandstone of southeastern Iowa are designated by (°), those present in the Chouteau limestone by (†)

FAUNAL TABLE IV—Continued.

Localities	Kinderhook, Ill.	Rockport, Ill.	Pleasant Hill, Ill.	Louisiana, Mo.
<i>Brachiopods—Cont'd</i>				
† Shumardella obsolens (Hall).....	—	—	x	—
Rhynchopora pustulosa (White).....	—	x	x	—
† Cranaena hannibalensis Moore.....	—	—	—	x
Cranaena sp.	—	—	—	x
° Spirifer marionensis Shumard ?.....	x	x	x	—
† Spirifer osagensis Swallow.....	—	—	—	x
° Spirifer subrotundus Hall.....	x	—	—	—
Brachythyris sp.	—	—	x	—
° Syringothyris extenuata (Hall).....	x	x	x	—
Syringothyris n. sp. (Chonopectus ss.)..	—	—	?	—
Syringothyris sp.	—	—	—	x
Martiniopsis sp.	—	x	x	—
† Ambocoelia parva Weller.....	—	x	x	—
° † Reticularia cooperensis (Swallow).....	—	x	x	—
Nucleospira barrisi White.....	—	—	—	?
° Nucleospira minima Weller.....	—	x	—	—
Athyris lamellosa (L'Eveille).....	—	x	—	—
Athyris sp.	—	—	x	—
<i>Pelecypods</i>				
Promacrus missouriensis Swallow ²	—	—	—	x
† Sphenotus iowensis Weller.....	—	—	—	x
Sphenotus sp.	—	—	—	x
° Grammysia plena Hall.....	x	—	—	?
Grammysia sp.	—	—	—	x
Cardiopsis radiata M. & W.....	—	—	—	x
Cardiopsis sp.	—	—	—	x
° Pteria strigosa (White).....	x	—	—	—
† Parallelodon blairi (Miller).....	?	—	—	x
Liopteria undulata M. & W.....	x	—	—	—
° Pteronites whitei (Winchell).....	x	—	—	—
Schizodus trigonalis (Winchell).....	—	—	—	?
Aviculopecten macwhorteri Worthen...	x	—	—	—
† Pernopecten circulus (Shumard).....	—	—	—	x
° † Pernopecten cooperensis (Shumard)....	x	—	—	x
Delopecten sp.	—	—	—	x
Delopecten sp.	—	—	—	x
° Goniophora jennae (Winchell).....	x	—	—	—
Lithophagus sp.	—	—	x	x
° † Cypricardinia sulcifera (Winchell).....	—	—	—	x
† Modiolus missouriensis Weller.....	—	—	—	x
<i>Gastropods</i>				
Bellerophon sp.	—	x	—	x
° Sphaerodoma pinguis Winchell.....	x	—	—	—
° Patellostium scriptiferum White.....	x	—	—	—
Bucanopsis perelegans (W. & W.).....	—	—	—	x
Platyceras nasutum Miller.....	—	—	x	—

FAUNAL TABLE IV—Continued.

Localities	Kinderhook, Ill.	Rockport, Ill.	Pleasant Hill, Ill.	Louisiana, Mo.
<i>Scaphopod</i>				
° Dentalium grandaevum Winchell	x	—	—	—
<i>Cephalopods</i>				
° Orthoceras indianense Hall	?	—	—	—
Orthoceras sp.	—	—	—	x
° Dawsonoceras heterocinctum (Winchell)	x	—	—	—
Aganides ? sp.	—	—	—	x

²The type specimen is said to have been collected from the Hannibal sandstone at Louisiana.

Correlation. The Hannibal section, containing the divisions which are readily traced throughout most of the northeastern portion of Missouri, is typical for that region. The type section of the Kinderhook group at Kinderhook, Illinois, which has been described on page 21, is only a few miles due east of the type section of the Hannibal formation on the opposite side of Mississippi river. So dissimilar, however, are the two sections, that it has never been possible to correlate satisfactorily between them. The Louisiana limestone, which is well exposed beneath the Hannibal beds at Hannibal, is not seen at Kinderhook, either because it is buried here or because it has pinched out. The Mississippi river has cut away the Kinderhook beds which intervened between the west bluffs and those on the east, but since the Hannibal and Louisiana formations are clearly recognized in Illinois south of Kinderhook it is possible to trace these beds northward. Near Pleasant Hill the Hannibal formation may be recognized without difficulty. It has the same lithologic characters, "vermicular" markings, and approximately the same thickness which are observed in Missouri; it is found immediately below the Sedalia limestone and, as the Louisiana limestone pinches out north of Belleview, it directly overlies the blue Saverton shale. About 4½ miles north of Pleasant Hill a section measured in the river bluffs shows a bed of fossiliferous brown fine-grained sandy magnesian limestone which is 61 feet below the top of the Hannibal.

The fauna of the limestone, listed in Faunal Table IV, consists very largely of brachiopods; most of the species are represented by a number of specimens. The limy bed, which is

absent only one-half mile farther south, becomes notably thicker in a northward direction. About one mile north of Rockport, it measures at least 18 feet. Shale beneath the limestone is well exposed but the upper Hannibal is mostly concealed. Fossils collected from the limestone here are identical with those observed north of Pleasant Hill, but the fauna is not quite so large. At Kinderhook the sandy magnesian limestone or limy sandstone occupies most of the upper part of the section. Its lithologic characters are identical with those which have been described but the thickness is 42 feet. At this locality the fossils are scattered through the entire sandy limestone division of the Kinderhook but are most abundant in a rather thin zone about 25 feet from the top. The fauna differs somewhat from those collected near Pleasant Hill and Rockport, the most striking change being the addition of an important pelecypod and gastropod element while some of the brachiopods and corals are lacking. The fauna at Kinderhook seems to bear closest resemblance to that bed in southeastern Iowa; a few Chouteau species are included in the faunas farther south in Pike county.

Approximately three-fourths of the species listed in Faunal Table IV are closely associated with either the Chouteau fauna of central Missouri or the English River (*Chonopectus*) horizon of southeastern Iowa. Of the remaining number one-half are known only from the localities here indicated, and for the sake of correlation may be disregarded. The affinities of the combined group, therefore, is preponderantly with the Chouteau on the one hand, and with the English River beds on the other.

Of the 24 English River species which occur in the foregoing list, practically all are to be found in the fauna of the magnesian beds at Kinderhook. Weller⁶⁷ has clearly shown this close relationship and it may be concluded with little question that, notwithstanding the absence of *Chonopectus* from Pike county, the sandy beds at Kinderhook are the equivalent of the so-called *Chonopectus* sandstone at Burlington.

The *Chonopectus* element is less pronounced in the remaining faunas which have been considered. In the Hannibal at Louisiana there are 8 species belonging to the typical *Chonopectus* fauna, in the collection north of Pleasant Hill, 5 species and at Rockport 4 species. The lower number of *Chonopectus* forms in the two last named faunas is due apparently, to the small proportion of molluscs, which may be due to local conditions at the time of deposition and without important significance other-

wise. It is to be observed, however that these faunas include some of the most characteristic of all the *Chonopectus* species, such as *Productus mesicostalis*, *Rhipidomella missouriensis*, and *Syringothyris extenuata*. *P. mesicostalis* is known elsewhere only in the English river (*Chonopectus*) sandstone at Burlington, and on English river in Washington county, Iowa. It is common in these beds and may be regarded as diagnostic of the horizon. *Rhipidomella missouriensis*, as shown by excellent specimens in the collections from Pleasant Hill and Rockport, is a minutely punctate shell, the punctations, unlike those of other Mississippian *Rhipidomellas*, closely resembling in their size and arrangement those of a terebratuloid like *Dielasma*. This rather peculiar feature is readily distinguished in well-preserved specimens of *R. missouriensis* associated with *Chonopectus fischeri* in Bed 3 at Burlington, Iowa. *Syringothyris extenuata* is a distinctive, easily recognized and characteristic species of the *Chonopectus* fauna to which important significance may be attached in the correlation of the limestone at Pleasant Hill and Rockport.

The element suggestive of the Chouteau in the collections under consideration, includes 19 species. Five of these, among them some of the most common Chouteau species such as *Reticularia cooperensis*, *Pustula concentrica* and *Pernopecten cooperensis*, are found in the *Chonopectus* fauna of southeastern Iowa and suggest in themselves a connection between the two faunas. The remaining Chouteau species are here for the first time described in association with the typical *Chonopectus* species. The fauna at Kinderhook is least suggestive of the Chouteau; those of Rockford and Pleasant Hill introduce a number of distinctive Chouteau types, viz., *Cyathaxonia tantilla*, *Zaphrentis chouteauensis*, *Shumardella missouriensis*, *S. obsolens*, and *Ambocoelia parva*. These species are in each case represented by a number of typical, well-preserved specimens, so that little doubt is attached to their identification. They are, nevertheless, found intimately associated with species which have been regarded as diagnostic of the *Chonopectus* horizon. An intermingling of this sort can only be interpreted to mean an actual intergradation of the two faunas.

The species identified as *Spirifer marionensis* (?) is abundantly represented in the collections north of Pleasant Hill and near Rockport, also with less well-defined characters at Kinderhook. They have the evenly elevated cardinal area and early

mucronate extensions of the hinge-line which are characteristic of *S. marionensis*¹ and the same flat fold and shallow sinus. The later growth of the shells in the Rockport and Pleasant Hill collections, however, is largely along the anterior margin, giving to them an elongate, obtusely rounded outline not characteristic of the typical Louisiana limestone species. Its plications, also, are somewhat finer than those of *S. marionensis*. The magnesian limestone specimens are probably distinct, though possibly closely related to typical *S. marionensis* and their presence with a species of *Productella* identified with *P. pyxidata* may indicate the derivation of a certain element in the faunas considered from the Louisiana limestone.

It appears from a study of the stratigraphic sections along Mississippi river that the Hannibal formation occupies an interval identical in position and approximately the same in thickness as the magnesian beds at Kinderhook which contain the *Chonopectus* fauna. There appears to be a gradual transition lithologically from the Hannibal, consisting of sandy shale and somewhat argillaceous sandstone, to impure magnesian limestone and intercalated fine sandstone beds of the *Chonopectus* type. There is also a gradual faunal change from the typical Hannibal at Louisiana to the magnesian beds at Kinderhook. The conditions suggested are those of essentially continuous and intergrading provinces in which more or less nearly contemporaneous deposits are chiefly distinguished by the different faunas associated with them. The local changes are illustrated by the distribution of *Chonopectus fischeri* which, though it literally crowds the horizon in southeastern Iowa in the vicinity of Burlington, is not known outside that region. On the evidence at hand the Hannibal formation may be regarded as the equivalent of the magnesian limestone and sandstone bed at Kinderhook, Illinois, and the *Chonopectus* beds at Burlington, Iowa. In the latter section it may include a portion of the lowest division, the shale of Bed 1.

The bluish drab limestone at Kinderhook, which is here termed the McKerney bed, contains only two known species of fossils, *Paryphorhynchus striatocostatum* and *Productella pyxidata*

¹The most important characters of *Spirifer marionensis* are the form of the cardinal area, which is nearly as high toward the extremities of the wings as near the beak and the very early attainment of the maximum width of hinge-line found in the mature shell. The plications are moderately broad and low, the fold is almost flat and the sinus hardly depressed below the general surface of the shell. The species is characteristic of the Louisiana limestone and possibly does not occur outside of that formation. It has commonly been confused with *S. osagensis* and similar shells of the Chouteau.

(?). Judged from the standpoint of this meager fauna and of lithology, there is nothing corresponding to this limestone in the Hannibal formation in Missouri. However, at Burlington, Iowa, the limestone (Beds 3 and 4) above the *Chonopectus*-bearing sandstone is lithologically similar to the McKerney bed at Kinderhook and it contains *Paryphorhynchus striatocostatum* together with 18 other specifically identified forms. Of this fauna 10 species occur in the Hannibal formation of Missouri and Illinois or the corresponding sandy beds in southeastern Iowa. Among these are *Rhynchopora pustulosa* which is known elsewhere only from the Hannibal in Illinois; *Syringothyris extenuata* which is known elsewhere only from the English River member of the Hannibal sandstone in Washington county, Iowa, at Burlington, and at Kinderhook, Illinois; *Rhipidomella missouriensis* which occurs in the Louisiana-Saverton fauna and in the Hannibal of Missouri and Illinois; *Chonopectus fischeri*, *Allorhynchus heteropse* and *Spirifer biplicatus* from the English River-Hannibal sandstone in Washington county and at Burlington, Iowa; and *Spirifer subrotundus* and *Chonetes alatus* from the Hannibal at Kinderhook and Burlington. Five species are known only from Beds 3 and 4 at Burlington. The fauna is preponderantly related to the Hannibal, as 79 per cent of the fossils found elsewhere occur in Hannibal beds. *P. striatocostatum*, which does not occur in the sandy beds of the Hannibal, connects the limestone at Burlington with that at Kinderhook. Since, as will be noted, the fauna of the yellow sandstone (Bed 5) at Burlington, indicates stronger relationship with the Hannibal than other Kinderhook formations and since the fauna of the subjacent limestone (Beds 3 and 4) is very closely related to the Hannibal, this limestone and that at Kinderhook are regarded as a member of that formation.

Bed 5 at Burlington contains a fauna with 54 specifically identified forms of which only 6 are restricted to this horizon and locality. Of the remaining 48 species, 39 occur in the Hannibal of southeastern Iowa and Missouri-Illinois. Nine species in the Bed 5 fauna do not occur in the Hannibal but are found in the Chouteau limestone. The relations thus appear to indicate that Bed 5 should be associated with the Hannibal, which also it resembles in general lithologic character. However, it is to be noted that the Hannibal itself is related to the Chouteau, and the fauna of Bed 5 contains 21 species that are common to Hannibal and Chouteau. Thus the Chouteau aspect of the upper sand-

stone at Burlington is little less pronounced than the association with the Hannibal. It is regarded here as the uppermost division of the Hannibal at Burlington, partly because of its faunal character and partly because of its sandy constitution.

The Hannibal formation has no equivalent in the central Missouri region but it may be at least partly contemporaneous with the Chouteau limestone of that district.

In southwestern Missouri the Northview formation of Kinderhook age has been correlated with the Hannibal because it corresponds in general lithologic character and has an apparently similar stratigraphic position. However, the limestone beneath the Northview, which has been classed as Louisiana by some writers, has a typical Chouteau fauna and is certainly not the Louisiana. Limestone identified as Chouteau is present in places above the Northview. Consideration of the evidence at hand leads to the view that the Hannibal and Northview are essentially equivalent, but there is sufficient uncertainty as to exact relations to make desirable the employment of separate names.

The Kinderhook of southeastern Missouri contains no formation corresponding to the Hannibal. The occurrence of fossiliferous strata (Glen Park limestone) beneath the Hannibal in western Illinois permits determination of the age of the corresponding Glen Park limestone of southwest Missouri as older than the Hannibal.

CHOUTEAU LIMESTONE

Locally within the northeast Missouri province there is developed at the top of the Kinderhook a bluish drab or light gray, compact to medium-grained limestone. The stratigraphic position, fossil content, and in part the lithologic character of this limestone are closely comparable to the Chouteau limestone of central Missouri. Accordingly the formation is designated Chouteau.

Distribution and thickness. Exceptionally fossiliferous Chouteau limestone is found in the northern part of the district in southeastern Knox county. These beds are admirably exposed along South Fabius river in the vicinity of Newark. To what extent the formation is continued westward and northward beneath the overlying formations and whether it is directly continuous with beds of the upper Kinderhook in Iowa, which

are also of Chouteau age, is not certain. The thickness of the Chouteau on South Fabius river is about 35 feet.

Southeast of Knox county, along the Mississippi and its tributaries in Marion, Ralls and Pike counties, where the upper beds of the Kinderhook are well exposed, the Chouteau limestone is mostly absent. The "Chouteau" which has been reported from this region by various writers^{22, 25, 44, 51} is a brown magnesian limestone that corresponds to the upper part of the Chouteau as it has been recognized in central Missouri. This upper division is lithologically and faunally distinct from the lower and it has seemed desirable to restrict the name Chouteau to the lower beds and to apply a new name (Sedalia) to the upper beds. The Sedalia limestone is recognized in northeastern Missouri and western Illinois, and corresponding beds are found in southeastern Iowa.

In southern Pike county and in Lincoln county there is a limestone beneath the Sedalia which is apparently referable to the Chouteau. On Mississippi river this limestone has an exposed thickness of about 20 feet but along Cuivre river east of Troy, it is more than 50 feet thick. The same limestone is observed east of Mississippi river in Calhoun and Jersey counties, Illinois, with unmistakable lithologic and faunal characters of the Chouteau. Its maximum observed thickness in this region is about 55 feet.

Lithologic character. In color, the Knox county Chouteau ranges from grayish drab and brown to almost white, the former predominating in the upper part of the formation, the latter in the lower. The brown limestone, which appears to represent partially dolomitized bands, occurs as distinct beds one or two feet in thickness, and as thin, irregular partings between the uneven, nodular drab beds of the upper division. The drab limestone, like the typical Chouteau of central Missouri, is extremely fine-grained, compact, and "lithographic" in texture. It is brittle and breaks with a sub-conchoidal fracture. The brown limestone is rather granular in texture, softer than the associated drab limestone and weathers more rapidly. Very tough, massive, brown limestone is locally developed which on the other hand, is very resistant to weathering. The light gray and white limestone in the lower part of the Chouteau is fine to medium-grained, sub-crystalline or completely crystalline and very pure. It is found in rather thin but even beds 2 to 8 inches in thickness which on weathering break into uneven, shelly fragments.

Both the compact and the crystalline limestones in the Chouteau are highly fossiliferous, the former containing a profusion of brachiopods, gastropods and pelecypods, the latter a number of brachiopods among which *Chonetes* is especially numerous. Chert is practically absent in the Chouteau of Knox county, but calcite geodes are observed in some of the formation.

The Chouteau limestone of southern Pike county, Missouri, and northern Calhoun county, Illinois, is a drab, compact, fine to medium-grained argillaceous limestone. It possesses the irregular, thin, nodular bedding and the shaly partings which are commonly observed in the Chouteau and weathers in the shelly, fragmental manner which is characteristic. In Lincoln county, Missouri, and southern Calhoun and Jersey counties, Illinois, the Chouteau is more closely similar to the central Missouri Chouteau than elsewhere in the region. The limestone is dark bluish drab, very compact, hard, dense and brittle, breaking with conchoidal fracture. It is thin-bedded and slightly nodular, with shale partings between the layers. Dark bluish or black flinty chert in bands 3 to 5 inches thick, and in discontinuous lenticular masses, is common in the Chouteau of this region.

Stratigraphy. The Knox county Chouteau limestone is exposed for two or three miles on South Fabius river in the vicinity of Newark, and in the bluffs of Little Fabius river and tributary streams. Section 8 (p. 73) measured on the south fork of Little Fabius river two miles southwest of Newark (NE. $\frac{1}{4}$ NW. $\frac{1}{4}$ sec. 26, T. 60 N., R. 10 W.) shows 35 feet of Chouteau.

In Marion county, Buehler² has reported the occurrence of the Chouteau limestone with a maximum thickness of 40 feet underlying crinoidal beds of the Burlington limestone.

The Chouteau of southern Pike county is best exposed in the vicinity of Annada about nine miles southeast of Clarksville. In the bluff south of the town it occupies the lower portion of the exposed rock face. The thin, nodular beds and the drab color of the formation are typical of the Chouteau, but only the upper part of the limestone is exposed (see section 9, p. 74).

On Cuivre river, 20 miles south of Annada, the lower beds of the Mississippian are brought to the surface by the Cap au Gres fault which extends westward from a point north of Winfield on Mississippi river, and passes north of Troy. The Chouteau is best seen in Frenchman's Bluff, about 6 miles northeast of Troy. Its lithologic character is almost identical with that of

the central Missouri Chouteau limestone but very few fossils were observed. Section 10 (p. 74) measured at this point shows 54 feet of Chouteau limestone.

On the east side of Mississippi river the writer traced the Chouteau from near Chautauqua in Jersey county to a point beyond Hamburg in the northwestern part of Calhoun county. The exposed thickness of the formation is more than 50 feet in some places.

Paleontologic character. The fauna of the Chouteau limestone which has been studied in the various parts of the northeast Missouri province is closely allied to the large and distinctive fauna of the type Chouteau in the central portion of the state. The Chouteau is abundantly fossiliferous in the Knox county exposures but in other places fossils are scant. On Little Fabius river, southwest of Newark, four faunal zones are distinguished, numbered in upward order (see section 8, p. 73). These are readily traced in the vicinity and some of the fossils, such as *Paryphorhynchus elongatum* appear closely restricted to a particular horizon within a faunal zone. In the following table columns marked A refer to collections made at the locality on Little Fabius river, known as Snake Den, and columns marked B indicate a locality about a quarter mile above Snake Den.

Faunal Table V.—Fauna of the Chouteau Limestone on Little Fabius River Near Newark, Knox County¹

Zones		1	2	3		4	
Localities		A	A	A	B	A	B
<i>Corals</i>							
	<i>Zaphrentis cliffordana</i> E. & H. ?	—	—	x	—	—	—
°	<i>Zaphrentis tenella</i> Miller	—	—	x	x	—	—
	<i>Zaphrentis</i> n. sp.	—	—	x	x	—	—
	<i>Zaphrentis</i> sp.	—	x	—	x	—	—
†	<i>Homalophyllum calceolum</i> (White)	—	x	—	x	—	—
	<i>Homalophyllum</i> sp.	—	—	—	x	—	—
†	<i>Leptopora typa</i> Winchell	—	x	—	—	—	x
	<i>Amplexus</i> n. sp.	—	—	—	—	—	x
<i>Bryozoans</i>							
°	† <i>Fistulipora</i> sp.	—	—	—	x	x	—
°	† <i>Leioclema</i> sp.	—	x	—	—	x	—
	† <i>Fenestella</i> sp.	x	x	x	3	4	2

¹Species known from the Chouteau limestone of central Missouri are designated by (°) and those from the Chouteau of Iowa by (†).

FAUNAL TABLE V—Continued.

Zones		1	2	3		4	
Localities		A	A	A	B	A	B
<i>Bryozoans—Cont'd</i>							
°	† Ptilopora sp.	—	—	—	—	x	—
°	† Rhombopora sp.	—	—	2	x	x	x
°	† Cystodictya sp.	x	—	x	x	x	x
<i>Brachiopods</i>							
°	† Leptaena analoga (Phillips)	—	x	x	—	—	x
	Schuchertella n. sp.	—	x	—	—	—	—
	† Schellwienella inflata (W. & W.)	x	?	?	—	—	—
°	Schellwienella chouteauensis Weller	x	—	—	—	—	—
	Schellwienella sp. 1.	—	x	x	x	—	x
	Schellwienella sp. 2.	—	x	—	—	—	—
°	Streptorhynchus tenuicostatum Weller	—	—	x	x	—	x
°	† Chonetes burlingtonensis Weller	x	—	x	x	x	?
°	Chonetes glenparkensis Weller	—	x	—	x	—	—
°	† Chonetes logani N. & P.	x	—	x	—	cf.	—
	Chonetes illinoisensis Worthen	—	x	x	—	—	—
	Chonetes sp.	—	x	—	2	—	—
°	† Productus arcuatus Hall	x	x	x	x	x	x
°	† Productus ovatus Hall	x	x	x	x	x	—
°	Productus sedaliensis Weller	—	x	x	—	x	x
°	† Pustula concentrica (Hall)	—	x	x	x	x	x
°	Pustula echinata Moore	x	—	—	—	—	—
°	Pustula newarkensis Moore	—	—	x	x	x	x
	Pustula sp.	—	—	x	—	—	—
	† Rhipidomella burlingtonensis Hall	—	—	x	—	x	—
°	† Rhipidomella tenuicostata Weller	—	—	—	—	x	—
°	Rhipidomella thiemei (White)	—	x	—	—	—	x
	Rhipidomella sp.	—	—	—	x	—	—
°	† Schizophoria chouteauensis Weller	—	x	x	—	x	—
°	† Camarotoechia chouteauensis Weller	—	—	x	x	x	x
°	Camarotoechia tuta (Miller)	x	—	x	x	x	x
	Camarotoechia sp.	—	—	—	x	—	—
°	Paryphorhynchus elongatum Weller	—	—	—	—	x	x
°	Shumardella missouriensis (Shumard)	—	—	—	—	x	—
°	Cranaena occidentalis (Miller)	—	—	—	x	x	x
	Cranaena sp.	—	—	—	—	—	x
°	Dielasma chouteauense Weller	—	—	x	—	x	x
	Cyrtina sp.	—	x	—	—	—	—
°	† Spiriferina subtexta White	—	—	x	x	—	—
	† Spirifer biplicoides Weller	—	x	x	—	x	x
	† Spirifer gregeri Weller	—	x	x	x	x	—
°	Spirifer louisianensis Rowley	—	x	x	x	x	x
°	Spirifer missouriensis Swallow	—	—	x	—	—	—
°	† Spirifer platynotus Weller	x	x	x	x	x	x
	Spirifer sp.	—	—	x	—	—	—
	† Brachythyris chouteauensis (Weller)	—	—	—	—	x	x

FAUNAL TABLE V—Continued.

Zones		1	2	3		4	
Localities		A	A	A	B	A	B
<i>Brachiopods—Cont'd</i>							
°	<i>Brachythyris peculiaris</i> (Shumard).....	?	x	x	x	—	—
†	<i>Syringothyris halli</i> Winchell ?.....	—	x	.	.	—	—
	<i>Syringothyris newarkensis</i> Weller.....	—	x	—	x	x	x
	<i>Syringothyris</i> sp.....	—	—	x	x	2	x
°	† <i>Reticularia cooperensis</i> (Swallow).....	—	x	x	x	x	x
	<i>Eumetria swallovi</i> Moore.....	—	—	—	—	—	x
	<i>Eumetria</i> sp.....	—	—	—	x	—	—
	<i>Nucleospira</i> sp.....	—	—	—	—	—	x
	<i>Camarophorella</i> sp.....	—	—	—	x	—	—
	<i>Athyris crassiscardinalis</i> White ?.....	—	—	—	x	.	—
°	† <i>Cliothyridina tenuilineata</i> (Rowley).....	—	—	x	x	x	x
	<i>Composita</i> sp.....	—	—	—	x	—	—
<i>Pelecypods</i>							
	<i>Sphenotus</i> sp.....	—	.	—	—	x	—
°	<i>Grammysia blairi</i> Miller.....	—	—	—	—	x	x
	<i>Grammysia</i> sp.....	—	—	—	—	x	—
	<i>Edmondia jejuna</i> Winchell ?.....	—	—	—	—	x	.
	<i>Edmondia albersi</i> M. & G. ?.....	—	—	—	—	—	x
	<i>Edmondia</i> sp.....	—	—	—	?	x	x
	<i>Parallelodon</i> ? sp.....	—	—	—	—	x	.
°	<i>Mytilarca jessieae</i> M. & G. ?.....	—	—	—	—	x	x
†	<i>Conocardium pulchellum</i> Winchell.....	—	—	—	—	—	x
†	<i>Spathella</i> ? sp.....	—	—	—	—	—	x
°	<i>Pterinopecten sedaliensis</i> Miller.....	—	—	—	—	x	x
	<i>Pterinopecten</i> sp.....	—	—	—	x	.	x
°	† <i>Pernopecten cooperensis</i> (Shumard).....	x	—	—	x	x	x
	<i>Pernopecten</i> sp.....	—	—	—	x	—	—
	<i>Modiolus</i> sp.....	—	—	—	—	x	—
†	<i>Lithophagus minutus</i> Weller ?.....	—	.	.	—	x	.
	<i>Lithophagus</i> ? sp.....	—	—	—	—	x	x
°	<i>Cypricardinia sulcifera</i> Winchell.....	—	—	—	—	x	x
	<i>Cypricardinia</i> sp.....	—	—	—	—	x	—
°	<i>Cypricardella eximia</i> M. & G.....	—	—	—	—	—	x
	<i>Palaeosolen occidentalis</i> M. & G.....	—	—	—	—	x	—
	<i>Pelecypod</i> n. gen., n. sp.....	—	—	—	—	x	—
<i>Gastropods</i>							
°	<i>Bellerophon blairi</i> M. & G.....	—	—	—	—	—	x
	<i>Bellerophon</i> sp.....	—	—	—	—	x	—
	<i>Bucanopsis</i> n. sp.....	—	—	—	—	x	—
°	<i>Pleurotomaria sedaliensis</i> Miller.....	—	—	—	—	x	—
	<i>Pleurotomaria</i> sp.....	—	—	x	—	x	—
	<i>Straparollus ammon</i> (W. & W.).....	—	x	.	—	?	—
	<i>Straparollus macromphalus</i> Winchell.....	—	—	—	x	—	—
†	<i>Straparollus obtusus</i> (Hall).....	—	x	—	—	—	x
°	<i>Straparollus missouriensis</i> Miller.....	—	—	—	—	—	x

FAUNAL TABLE V—Continued.

Zones		1	2	3		4	
Localities		A	A	A	B	A	B
<i>Gastropods—Cont'd</i>							
°	Straparollus lens (Hall).....	—	—	—	—	x	—
	Straparollus sp.....	x	—	—	—	—	—
°	† Strophostylus bivalve (W. & W.).....	—	x	—	x	x	x
°	Loxonema tenuilineatum (Shumard).....	—	—	—	—	x	x
	Loxonema sp.....	—	—	—	—	3	x
°	Holopea blairi Miller.....	—	—	—	—	x	—
	Holopea sp.....	—	—	—	—	—	x
°	Platyceras haliotoides M. & W.....	—	x	x	x	—	—
°	Platyceras nasutum Miller.....	—	x	—	x	cf.	—
	Platyceras sp.....	—	—	—	x	—	x
<i>Scaphopod</i>							
	† Dentalium grandaevum Winchell.....	—	—	—	—	—	x
<i>Cephalopods</i>							
	† Orthoceras indianense Hall.....	—	—	—	—	x	—
	Orthoceras sp. cf. O. chemungense.....	—	—	—	—	x	—
	Orthoceras sp.....	—	—	—	—	x	—
	Cyrtoceras caniniforme Moore.....	—	—	—	—	—	x
°	Triboloceras digonum (M. & W.).....	—	—	—	—	x	—
°	Phragmoceras missouriense Miller ?.....	—	—	—	—	x	—
°	Poterioceras missouriense Miller.....	—	—	—	—	—	x
<i>Crustaceans</i>							
□	Proetus swallowi Shumard ?.....	—	x	—	x	—	—
	Proetus ? sp.....	x	—	—	—	x	—
°	Phillipsia sampsoni Vogdes ?.....	—	x	—	—	cf.	—
	Phillipsia ? sp. cf. P. concors Herrick.....	—	—	—	—	x	—
	Phillipsia ? sp.....	—	x	—	—	x	—
°	Griffithides ? sedaliensis Vogdes ?.....	—	—	—	—	x	—
°	Brachymetopus armatus Vogdes.....	—	—	—	x	x	x
	Brachymetopus n. sp.....	—	—	—	—	x	—

The Chouteau of the southern part of the northeast region is very unfossiliferous. A few fossils collected from the poorly fossiliferous beds on Cuivre river, Lincoln county, consist chiefly of species of corals and molluscs closely resembling specimens from the central Missouri Chouteau (Faunal Table VI). In Calhoun county, Illinois, the fauna of the Chouteau is similar to that of central Missouri, although the beds are not so fossiliferous and the number of species which have been recognized is not so large. A collection made by Dr. Stuart Weller on Dogtown creek, in the southwestern part of Calhoun county contains species listed in Faunal Table VI, identifications by the writer.

Faunal Table VI.—Fauna of the Chouteau Limestone in Lincoln County, Mo., and Calhoun County, Ill.

Locality	Calhoun Co., Ill.	Lincoln Co., Mo.
<i>Coral</i> s		
<i>Zaphrentis tenella</i> Miller.....	—	x
<i>Zaphrentis</i> sp.....	—	x
<i>Zaphrentis</i> sp.....	—	x
<i>Amplexus blairi</i> Miller ?.....	—	x
<i>Amplexus corniculus</i> Miller ?.....	x	—
<i>Monilopora</i> sp.....	—	x
<i>Blastoid</i>		
<i>Schizoblastus roemeri</i> (Shumard).....	—	x
<i>Bryozoans</i>		
<i>Fenestella</i> sp.....	—	x
<i>Fenestella</i> sp.....	—	x
<i>Fenestella</i> sp.....	—	x
<i>Pinnatopora</i> sp.....	—	x
<i>Rhombopora</i> sp.....	x	—
<i>Rhombopora</i> sp.....	—	x
<i>Cystodictya</i> sp.....	—	x
<i>Brachiopods</i>		
<i>Glossina sedaliensis</i> (Miller).....	x	—
<i>Leptaena analoga</i> (Phillips).....	x	—
<i>Schellwienella</i> sp.....	x	—
<i>Schellwienella</i> sp.....	x	—
<i>Chonetes logani</i> N. & P.....	x	—
<i>Chonetes burlingtonensis</i> Weller ?.....	—	x
<i>Chonetes</i> sp.....	x	x
<i>Productus</i> sp.....	x	—
<i>Avonia</i> ? <i>blairi</i> (Miller).....	x	—
<i>Pustula concentrica</i> (Hall).....	x	—
<i>Pustula newarkensis</i> Moore.....	x	—
<i>Rhipidomella tenuicostata</i> Weller.....	x	x
<i>Camarotoechia chouteauensis</i> Weller.....	x	?
<i>Camarotoechia tuta</i> (Miller).....	x	—
<i>Camarotoechia</i> sp.....	—	x
<i>Shumardella obsolens</i> (Hall).....	x	—
<i>Rhynchopora</i> ? <i>cooperensis</i> (Shumard) ?.....	x	—
<i>Cranaena occidentalis</i> (Miller).....	x	—
<i>Dielasma chouteauense</i> Weller.....	x	—
<i>Spiriferina subtexta</i> White.....	—	x
<i>Spirifer louisianensis</i> Rowley.....	x	—
<i>Spirifer osagensis</i> Swallow.....	x	—
<i>Brachythyris peculiaris</i> (Shumard).....	x	—
<i>Syringothyris missouri</i> Hall & Clarke.....	x	—
<i>Reticularia cooperensis</i> (Swallow).....	x	—
<i>Athyris lamellosa</i> (L'Eveille).....	x	—
<i>Pelecypods</i>		
<i>Sphenotus sinuatus</i> M. & G.....	x	—
<i>Edmondia sedaliensis</i> (M. & G.).....	x	—

FAUNAL TABLE VI—Continued.

Locality	Calhoun Co., Ill.	Lincoln Co., Mo.
<i>Pelecypods—Cont'd</i>		
Edmondia blairi (Miller) ?	—	x
Edmondia n. sp. (Pettis Co.)	—	x
Edmondia sp.	x	—
Edmondia sp.	x	—
Parallelodon blairi (M. & G.)	x	—
Parallelodon sp.	x	—
Schizodus sp.	x	—
Schizodus sp.	x	—
Pernopecten cooperensis (Shumard)	x	—
Lithophagus sp.	x	—
Cypricardinia sulcifera Winchell	x	—
Cypricardella eximia M. & G.	x	?
Pelecypod gen., sp. ?	—	x
<i>Gastropods</i>		
Bellerophon blairi M. & G. ?	x	—
Bellerophon sp.	x	—
Bucanopsis ? sp.	x	—
Pleurotomaria sp.	x	—
Straparollus sp.	x	—
Loxonema tenuilineatum (Shumard)	x	x
Holopea blairi (M. & G.)	x	—
Holopea sp.	x	x
Platyceras haliotoides M. & W.	x	—
Platyceras paraliu W. & W.	x	—
<i>Cephalopods</i>		
Orthoceras chouteauense Swallow	x	—
Orthoceras sp.	x	—
Triboloceras digonum (M. & W.)	x	—
Muensteroceras osagense (Swallow) ?	x	—
<i>Crustaceans</i>		
Phillipsia sp.	x	—
Griffithides ? sedaliensis Vogdes	x	—

Correlation. Comparison of the known Chouteau fauna from northeastern Missouri with that of the type region in central Missouri indicates close relationship. There are 92 identified species in the northeastern fauna, and of this number only 8 appear to be restricted to it. Species common to the northeastern and central Missouri Chouteau are 72, or practically 80 per cent of the northeastern fauna. Most of the characteristic Chouteau fossils are included in this common group, and accordingly there can be no question but that the sea of Chouteau time spread uninterruptedly over the two regions compared.

There are 37 species which are reported only from the Chouteau of northeastern and central Missouri.

The common occurrence of *Paryphorphynchus* in the Chouteau beds near Newark is of interest, for this genus has been regarded by Weller⁶⁷ as one of the distinctively northern types in the Kinderhook faunas. It is represented by species in the lower beds at Burlington, in the limestone at Kinderhook, and extends as far eastward as Pennsylvania; on the other hand it had not been observed in the typical Chouteau fauna of Missouri. However, Greger¹³ has reported *Paryphorphynchus* from Montgomery county; the writer has found the genus in the lower Chouteau beds at Sweeney, in Pettis county; and Olive Hoffman¹ and E. B. Branson¹ have collected numerous specimens from other places in central Missouri. This rhynchonelloid is not only common locally in the northeastern Missouri Chouteau but extends almost to the southwestern part of the state. Increasing information concerning the Kinderhook faunas suggests that the sharply distinct faunal provinces that have been thought to distinguish the early Mississippian are probably only faunal variations in more or less connected waterways.

The upper Kinderhook beds at Burlington, Iowa, contain a fauna which is strongly Chouteau in aspect. The upper yellow sandstone (Bed 5) contains many Chouteau species, but it has been pointed out that faunal and lithologic similarities make this bed a probable correlative of the uppermost Hannibal and it is so classified in this study. Bed 6 at Burlington is a white limestone that contains a known fauna of 26 specifically identified invertebrates, and of this number all but two are found in the Chouteau limestone. This fact and the presence of many most characteristic Chouteau fossils indicate that this limestone represents the Chouteau. The overlying magnesian limestone (Bed 7) at Burlington appears to belong to the Sedalia horizon.

The Kinderhook formations of Iowa have recently been described by Van Tuyl⁵⁹ and his record of the fauna in these beds affords basis for comparison with the Missouri Chouteau. Excluding the lower shale and sandstone strata which lithologically and faunally are evidently most closely related to the Hannibal of northeastern Missouri, the remaining Kinderhook of Iowa consists mainly of limestone which increases in thickness northwestward. Limestone equivalent to the Chouteau (Bed 6) at Burlington is present in southeastern Iowa although

¹Personal communication.

the deposit is thin and is not separately named. The succeeding brown dolomitic beds, designated Wassonville limestone in Washington county (equivalent to Sedalia), are thicker than at Burlington. In Marshall county, central Iowa, the LeGrand limestone at least 62 feet thick, is reported as Kinderhook. Near the top of the LeGrand beds is a remarkable crinoid fauna which is widely known. The fauna is only partly studied, many of the recorded fossils being only identified generically, but it seems clear that both the Chouteau and Sedalia of Missouri are represented. In north central Iowa Van Tuyl has distinguished six formations in the Kinderhook; these consist of shale, limestone and dolomite. The reported faunas are insufficient for definite correlation but both the Chouteau and Sedalia apparently are represented. Taking together all of the specifically identified fossils from the Iowa Kinderhook, excepting those from Hannibal equivalents in southeastern Iowa, a total of 116 species is found. Of this number 66 species, including 34 crinoids, are not found in Missouri, but 42 out of the remaining 50 species occur in the Chouteau limestone of northeastern Missouri. There are 25 species common to the Chouteau of central Missouri and Iowa. Twelve of the Iowa species occur in northeastern Missouri but not elsewhere in the state.

East of the Pennsylvanian area in Illinois and Indiana the Kinderhook is represented by the Rockford limestone, a thin deposit which is traced across part of Indiana. Its fauna has long been known because of its interesting cephalopods that ally it on the one hand with early Mississippian deposits in Europe and on the other with the Chouteau of Missouri. Only one of these cephalopods, *Triboloceras digonum*, is at present known from the northeastern Missouri Chouteau, and of the 36 species in the Rockford fauna only 7 occur in the region here considered. Though so distinctive and specialized a form as *Prodromites gorbyi* occurs in the Rockford and central Missouri Chouteau, the number of common species is only 9. Notwithstanding this absence of close faunal relationship, the Rockford and Chouteau are believed to be contemporaneous, at least in part.

STRATIGRAPHIC SECTIONS

(3) Section on South Fork of North River, Marion County

	Drift.	Thickness	
		Feet.	Inches.
Kinderhook group			
	Hannibal formation		
	3. Shale, bluish green, sandy, and soft sandstone filled with tubular cavities.	65	
	Louisiana limestone		
	2. Limestone, fine-grained, gray to buff, containing crystals and small geodes of calcite. Regularly bedded.	30	
	Saverton shale		
	1. Shale bluish, slightly arenaceous. Exposed.	35	

(4) Section at Lovers Leap, South of Hannibal, Marion County

		Thickness	
		Feet.	Inches.
Osage group			
	Burlington limestone (Upper and Lower)		
	6. Limestone, light gray and brown, coarse crystalline, massive, alternating with medium- to fine-grained magnesian, cherty limestone, partly covered. Sedalia at base ? (See section 38, p. 171)	120	‡
	<i>Disconformity</i>		
Kinderhook group			
	Hannibal formation		
	5. Sandstone, bulish green, fine-grained, soft and shaly, and shale, bluish or brownish green, arenaceous.	67	
	Louisiana limestone		
	4. Limestone, buff, fine-grained, magnesian, a single massive layer. Upper surface irregular, due apparently, to an erosion interval between the Louisiana and the Hannibal.	0-2	
	3. Limestone, drab and light brown or buff, in alternating beds. The drab limestone is pure, compact, dense, "lithographic" in texture, breaking with sharply conchoidal fracture, weathering to light drab gray. The brown limestone is dolomitic, granular in texture, with subconchoidal fracture, weathering light buff. Small calcite-filled geodes. Beds very thin, 1 to 1½ inches.	5	
	2. Limestone, lithologically like (2) but with thicker beds. . . .	23-24	
	1. Limestone (concealed)	25	‡

(5) Section at Louisiana, Pike County, Missouri

		Thickness	
		Feet.	Inches.
	Soil and residual clay, with abundant chert.	4	
Mississippian			
	Osage group		
	Burlington limestone		
	3. Limestone, brown, thin-bedded, cherty, fine- to coarse-grained, crinoidal (Upper Burlington)	20	
	2. Limestone, brown and white, in alternating massive layers, coarse-grained, crinoidal. Chert in bands and nodules. (Lower Burlington)	39-40	
	<i>Disconformity</i>		
Kinderhook group			
	Hannibal formation		
	11. Sandstone, brown, soft, shaly, with abundant vermicular markings.	6-12	
	10. Shale, brownish green, sandy, soft.	65-70	
	Louisiana limestone		
	9. Limestone, buff to brownish gray, mottled pure and dolomitized limestone, compact, fine-grained, in layers 3 to 6 inches thick. The pure limestone, dense, "lithographic" in texture, with sharply conchoidal fractures. The dolomitic limestone is fine granular, with subconchoidal fracture.	35	

		Thickness Feet. Inches.	
	8. Limestone similar to above, slightly thicker and less magnesian.....	8	
	7. Limestone similar to above. Beds separated by thin sandy partings containing fossils. Light gray in color, fairly uniform.....	6	
	Saverton shale		
	6. Shale, buff, sandy, fossiliferous.....	2-6	
	5. Shale, green or dark blue.....	2	
	Grassy Creek shale		
	4. Shale black, fissile		
	<i>Unconformity</i>		
Silurian	Edgewood limestone (Alexandrian)		
	3. Dolomite, buff, massive.....	2-3	
	2. Limestone, oolitic, white, massive (Noix oolite member)	6-8	
	<i>Unconformity</i>		
Ordovician	Maquoketa shale		
	1. Shale blue, calcareous, with thin limestone bands.....	3-10	
(6) Section at Pinnacle Hill, Clarksville, Pike County			
		Thickness Feet. Inches.	
Mississippian	Osage group		
	Burlington limestone (Lower)		
	12. Limestone, light gray and buff, medium- to coarse-grained, crinoidal, massive, chert in bands and nodules	35	
	Sedalia limestone		
	11. Limestone, brown, magnesian, ferruginous, hard, very massive.....	7	6
	10. Limestone, buff, to yellowish, soft, massive, contains iron-stained casts of fossils and pore spaces due to leaching of scattered calcite fragments, weathers forming a recess in cliff profile.....	5	6
	9. Limestone, buff to light brown, soft, friable, containing fossil casts, weathers readily.....	2	6
	<i>Disconformity</i>		
	Kinderhook group		
	Hannibal formation		
	8. Sandstone, dark bluish green to brown, fine-grained, massive, containing numerous well-marked "vermicular" markings.....	8	
	7. Shale, sandy, bluish-green, soft, grading into sandstone at the top, partly covered.....	72-80	
	Louisiana limestone		
	6. Limestone, gray to buff, mottled pure and dolomitic, in thin beds, fine-grained, "lithographic," with sharply conical fracture. Bedding notably thinner toward top.	30	
	Saverton shale		
	5. Shale yellow, sandy.....		4-6
	4. Shale blue, somewhat arenaceous, hard, the beds thicker than in underlying shale.....	2	
	Grassy Creek shale		
	3. Shale, black, fissile. It rests with distinctly irregular contact on the underlying limestone.....	3	
	<i>Unconformity</i>		
Silurian	Edgewood limestone (Alexandrian)		
	2. Dolomite, yellow to light brown, very massive, medium-grained.....	24	
	<i>Unconformity</i>		
Ordovician	Maquoketa shale		
	1. Shale, blue calcareous (near Clarksville).....	40	

(7) Section on Noix Creek Near Bowling Green, Pike County

		Thickness	
		Feet.	Inches.
Osage group			
Burlington limestone (Lower)			
8.	Limestone, bluish, hard, crystalline, massive.	2	
7.	Limestone, white, medium-grained, crystalline, non-cherty, massive, fossiliferous.	14	
6.	Limestone, light gray in upper part, brownish in lower part, crinoidal.	5	6
Sedalia limestone			
5.	Limestone, grayish drab, hard, subcrystalline, massive, weathers brown and forms rounded surfaces.	5	
4.	Limestone, buff, compact, thin-bedded, medium- to fine-grained, fossiliferous.	5	
3.	Limestone, brown, earthy fine-grained, compact, weathers gray. Beds range in thickness from a few inches to 1 foot. . .	6	
<i>Disconformity</i>			
Kinderhook group			
Hannibal formation			
2	Sandstone, greenish-drab, fine-grained, compact, hard, a single massive layer; weathers brownish-green, and forms rounded surfaces.	5	
1.	Shale, bluish, sandy in upper part (exposed).	22	

(8) Section on South Branch of Little Fabius River, Southwest of Newark, Knox County
NE $\frac{1}{4}$ NW $\frac{1}{4}$ Sec. 26, T. 60 N., R. 10 W.

		Thickness	
		Feet.	Inches.
Osage group			
Burlington limestone (Lower)			
13.	Limestone, gray, coarse-grained, crinoidal, crystalline, very massive.	8	
12.	Limestone, light gray to brownish, crinoidal, contains much interbedded chert, stylolites common.	5	6
11.	Limestone, brown, dolomitic, coarse-grained, crinoidal, very massive, contains numerous stylolites.	5	6
Sedalia limestone			
10.	Limestone, light brown, fine-grained, massive, magnesian, porous, weathering readily to form recess in cliff profile. Contains dark chert bands about 1 foot apart.	6	6
9.	Limestone, light gray to brown, fine-grained, massive, contains stylolites, and two nodular chert bands.	7	
8.	Limestone, gray to brownish, coarse-grained, crystalline, contains stylolites.	3	
7.	Limestone, hard, creamy to yellowish, a single massive layer, fine-grained.	2	
<i>Disconformity ?</i>			
Kinderhook group			
Chouteau limestone			
6.	Limestone, light drab and yellowish brown, in thin, irregularly alternating beds. The drab limestone is fine-grained, hard, compact, brittle, with sharply conchoidal fracture; the brown limestone is magnesian, granular in texture, and soft. A massive brown limestone near the middle. Very fossiliferous. (Zone 4)	9-10	
5.	Limestone, brownish gray, medium-grained, partly crystalline, in somewhat lenticular beds alternating with thin, drab and brown beds like the division above. Fossiliferous. (Zone 3)	3-4	
4.	Limestone, bluish drab to brown, medium grained, argillaceous, with scattered patches of crystalline limestone in thin beds. Fossiliferous. (Zone 2)	5-6	

	Thickness Feet. Inches.
3. Limestone, white to light gray, subcrystalline, fine- to medium-grained, crystalline, in beds 2 to 8 inches thick, weathering in uneven, shelly fragments. Very fossiliferous. (Zone 1)	14
2. Limestone, yellowish brown, impure, arenaceous, medium-grained, thin-bedded.	2
Hannibal formation ?	
1. Shale, blue to bluish-green, soft, arenaceous, exposed in bed of river.	1

(9) Section at Annada, Pike County

	Thickness Feet. Inches.
Osage group	
Burlington limestone (Lower)	
4. Limestone, white to gray, coarse-grained, crystalline, crinoidal, medium to massively bedded, with chert in bands and nodules	40
Sedalia limestone	
3. Limestone, yellowish brown, silico-magnesian, fine-grained, compact, tough, massively bedded, breaking off in slabs along joints obliquely inclined to bedding.	29
Disconformity ?	
Kinderhook group	
Chouteau limestone	
2. Limestone, bluish-gray to drab, fine-grained, argillaceous, with numerous small fossil fragments, beds nodular, thin, uneven, with thin shale partings. It lacks the compact, dense, character and sharply conchoidal fracture of the typical Chouteau	17
1. Covered to bottom of hill.	125

(10) Section at Frenchman's Bluff, Cuivre River, Six Miles Northeast of Troy, Lincoln County

	Thickness Feet. Inches.
Osage group	
Burlington limestone (Lower)	
9. Limestone, light bluish and brownish gray, medium- to coarse-grained, crystalline, crinoidal, massively bedded, fossiliferous.	35
Sedalia limestone	
8. Limestone, brownish-gray to buff, magnesian, fine- to medium-grained, very massive, weathering in rounded surfaces.	11
Disconformity ?	
Kinderhook group	
Chouteau limestone	
7. Limestone, bluish drab, hard, dense, compact, thin-bedded, weathering in shelly, irregular fragments.	12 6
6. Limestone, greenish gray, argillaceous, beds thicker than in overlying division.	2 2
5. Shale, yellowish brown, with sandy bands. Chert nodules and thin bands.	2 6
4. Limestone, greenish gray, very impure, argillaceous. Contains calcite geodes. Massive.	16 3
3. Limestone, light blue, shaly, fine-grained, compact, with chert in thin, persistent bands 2 to 4 inches thick.	6 6
2. Limestone, dark bluish drab, argillaceous, fine-grained, compact, hard, dense, very thin-bedded.	13
1. Covered to level of river.	51

SUMMARY

Grassy Creek shale. The Grassy Creek shale is a relatively thin formation consisting of black, fissile shale which outcrops in Pike county, Missouri, and in Pike and Calhoun counties, Illinois. It ranges in thickness from 1 to 45 feet. Its known fauna consisting of a few fish remains and Lingulas, aids little in correlation, but from the fact that the formation immediately overlies an unconformity of importance, and conforms closely in its stratigraphic relations and distribution to the overlying beds of the Kinderhook, it seems best to regard it as the initial Kinderhook deposit in this region. It is possibly equivalent to a portion of the Chattanooga shale.

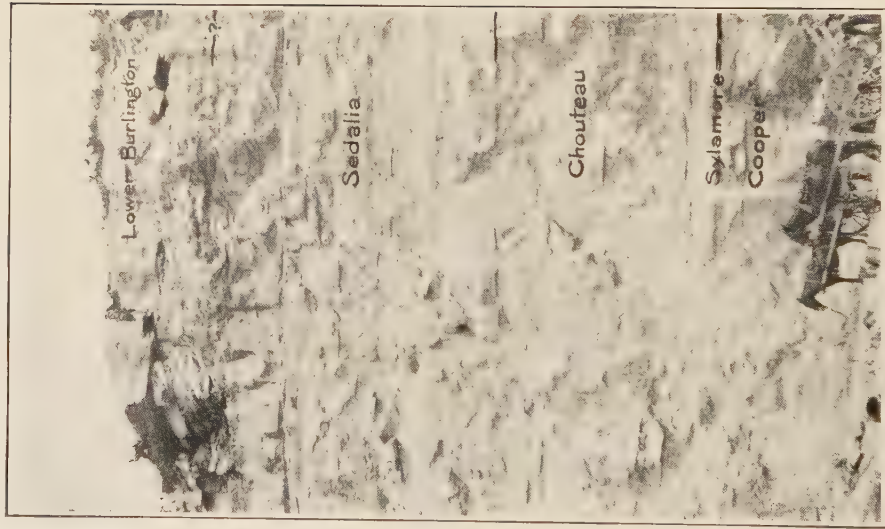
Saverton shale. The Saverton formation is a blue or bluish green shale extending throughout most of northeast Missouri and adjacent parts of Illinois, and probably reaching northward a considerable distance toward Iowa. Its thickness ranges from nearly 100 feet, in Ralls county, to less than 1 foot in southern Pike county, Missouri, and Calhoun county, Illinois. It is apparently conformable on the Grassy Creek shale and passes without physical or faunal break into the overlying Louisiana limestone. The fauna of the Saverton consists of a large number of invertebrates practically identical with species from the Louisiana, and an important group of fishes, which previously have been interpreted as proof of the Devonian age of the formation. However, analysis shows that characteristic Mississippian fishes are present and that the remaining forms cannot be regarded as diagnostic of the Devonian. Both physical and faunal evidence seems to favor the reference of the Saverton shale to the lower portion of the Kinderhook.

Louisiana limestone. The Louisiana limestone is a lenticular formation consisting of compact, lithographic, drab limestone. It is apparently restricted in its distribution to the northeastern part of Missouri and the adjacent portion of Illinois. Its maximum thickness, measured a short distance south of Hannibal, is about 65 feet. From this maximum the formation becomes thinner in all directions, rather gradually in a north-south direction, with remarkable abruptness toward the east and west. The fauna of the Louisiana is distinctive but is largely restricted to the lower few feet of the formation. It contains Devonian elements, but these are counterbalanced by distinctly Mississippian features. There is good reason for placing the formation in the Kinderhook. The Louisiana is most closely related

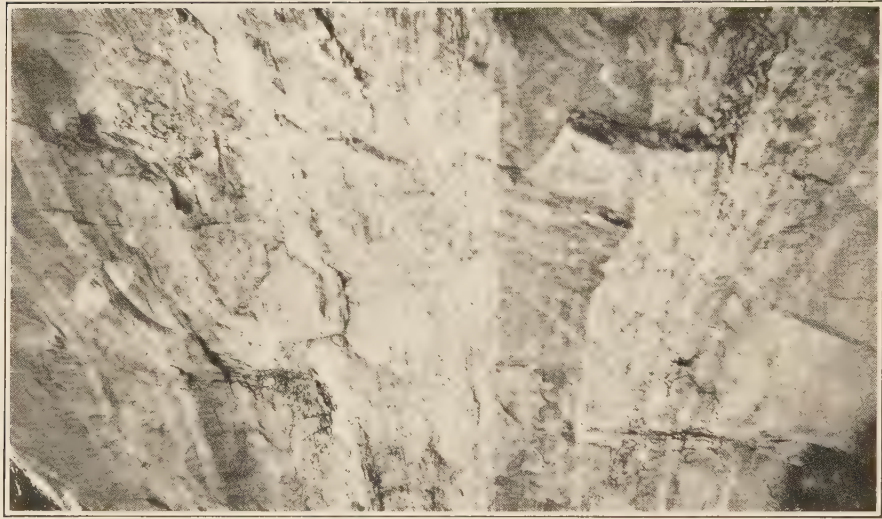
faunally to the subjacent Saverton shale, but lacks the fish fauna of the latter. It is faunally very different from any other Kinderhook formation. The Louisiana disconformably underlies the Glen Park limestone in Calhoun county, Illinois.

Hannibal formation. The Hannibal formation includes the more or less arenaceous upper Kinderhook beds of northeastern Missouri and the adjacent portion of Illinois. It consists of bluish green sandy shale and soft "vermicular" sandstone, but in Pike county, Illinois, it appears to grade laterally into an impure, magnesian limestone. In thickness the Hannibal ranges from a very few feet to nearly 100 feet, measured in the vicinity of Clarksville. The fauna of the Hannibal is not large, but the species which have been recognized suggest correlation with the Chouteau fauna on the one hand, and on the other with the *Chonopectus*-bearing English Piver sandstone of southeastern Iowa. Evidence of equivalence of the Hannibal and *Chonopectus* beds is found in similar lithologic character, stratigraphic relations, and the occurrence of transitional faunas in Pike county, Illinois. The upper limestone at Kinderhook is correlated with beds 3 and 4 at Burlington and classed as a member of the Hannibal. The upper sandstone (Bed 5) at Burlington is regarded as uppermost Hannibal.

Chouteau limestone. The Chouteau limestone is typically though not extensively developed in northeastern Missouri. Lithologically the beds are somewhat unlike those of the central Missouri Chouteau consisting of almost white, medium-grained, crystalline rock, as well as compact, dense drab limestone. The Chouteau of the southeast part of the province is very like the typical Chouteau both in texture and in peculiarities of bedding. The thickness observed in Knox county is 35 feet, in Lincoln, Calhoun and Jersey counties, 50 to 55 feet. The fauna of the Knox county Chouteau is closely related to that in central Missouri on the one hand, and on the other to the upper Kinderhook beds at Burlington, especially Bed 6. It therefore serves to connect the typical Chouteau with the Kinderhook section of southeastern Iowa. The fauna of the Chouteau in Illinois, is similar to that of central Missouri, and the beds of this locality doubtless represent a direct continuation of the formation as observed farther west.



A. Quarry of the M., K. & T. Ry. at Sweeney, Cooper County.



B. A fresh exposure of the Chouteau limestone in the quarry at Easley, Boone County.

THE CENTRAL MISSOURI KINDERHOOK

INTRODUCTION

The Kinderhook of the central part of Missouri differs in a number of respects from that of other portions of the state. Instead of the varying succession of sandstone, shale and limestone which characterizes the series in northeastern and southwestern Missouri, the Kinderhook in this region consists almost entirely of a single formation, the Chouteau limestone. Beneath the Chouteau is a persistent, generally very thin sandstone, the Sylamore, so inconspicuous that in many exposures it might easily be overlooked.

Distribution and thickness. Beds of Kinderhook age are exposed on the north side of Missouri River from St. Charles county to Howard county and on the south side of the river in Moniteau, Cooper, Saline and Pettis counties. Thickness varies from a maximum of nearly 60 feet in the west portion of the district, to less than 1 foot at a number of localities in the eastern part of the area.

Lithologic character. At the base of the Kinderhook in this region is a thin, somewhat discontinuous stratum of soft, calcareous greenish sandstone. The remainder of the Kinderhook is composed of fine-grained, compact, drab limestone. In the western part, where the Chouteau is best developed, the basal sandstone is only a few inches thick, but in the eastern counties the sandstone increases locally, so that it appears more important than the superjacent limestone.

Structure. The Kinderhook has a slight but rather uniform dip to the northwest away from the Ozark dome and in this direction the Kinderhook disappears beneath higher beds. In wells which have been drilled in the northwestern part of the state, strata belonging to the group are recognized at increasing depths beneath the surface. In Howard and Saline counties a small anticline crossing Missouri river in a direction slightly north of east, carries the Kinderhook well above the level of the river. How far this small but well defined anticline is continued in the direction of its strike is not known.

Divisions. The formations included in the Kinderhook of central Missouri are:

Chouteau limestone (restricted).

Sylamore sandstone.

The Sylamore sandstone, named from exposures in northern Arkansas,⁷⁶ is the thin calcareous sandstone at the base of the Kinderhook in this region. Its presence in Saline county was observed by Meek.³¹ At Providence, Boone county, it was designated by Stewart⁵⁰ as a "greenish, arenaceous band." Broadhead⁶ described a sandstone, which he termed the "Old Red Sandstone," at the base of the Mississippian and unconformable upon the Devonian of Warren county.

The Chouteau limestone was named by Swallow⁵¹ from exposures at Chouteau Springs, Cooper county. Swallow included in the Chouteau (b) an upper division of brownish gray, siliceous, rather unfossiliferous dolomite, and (a) a lower member consisting of dark drab, compact, brittle limestone containing an abundant and very characteristic fauna. Examination of the faunal and stratigraphic relations of the upper division indicates that it is distinct from the lower. Since the "Upper Chouteau" is different in lithologic character, areal distribution, fauna and stratigraphic relations, it has appeared desirable to distinguish it as a separate formation that is here classed as a basal portion of the Osage group. From exposures in the vicinity of Sedalia, Pettis county, the name Sedalia limestone is proposed. The Chouteau limestone is here restricted to include only the lower divisions of compact, drab, fossiliferous limestone.

Swallow has reported the presence of the "Vermicular sandstone and shale" in considerable thickness in Cooper county. Examination by the writer of localities mentioned by Swallow and of descriptions of the lithologic character of the supposed "Vermicular" make it clear that portions of the "Upper Chouteau" or Sedalia limestone were mistaken for the northeast Missouri formation. The "Lithographic" (Louisiana) limestone which is also described by Swallow in Cooper county,^{51a} on LaMine river, is certainly the Chouteau. The Louisiana limestone and Hannibal shale were doubtfully reported in Moniteau county by Van Horn,⁵⁸ but investigation of the faunas indicates that the beds in question belong to the Chouteau.

Pre-Kinderhook unconformity. Beneath the Kinderhook in Cooper, Pettis and Boone counties is the drab gray Cooper limestone of Middle Devonian age. This limestone is widespread near Sedalia, at Sweeney, and along the Missouri river.

It has been reported by Meek³¹ beneath the Chouteau limestone on Blackwater river in Saline county. Slight irregularities in the upper surface of the Devonian limestone, variation in its thickness and discordance in its bedding as compared with the Kinderhook, indicate unconformity. Between Easley and Providence, on the north side of Missouri river, exposures are almost continuous in the bluffs and in railroad cuts of the Missouri, Kansas and Texas Railway. The Kinderhook rests on limestone probably representative of the Callaway,⁵ but about one mile southeast of Providence, a shale appears beneath the Sylamore sandstone.

In Moniteau county the Devonian limestone and shale are lacking in some localities, for the Sylamore including rounded, water-worn pebbles of chert and quartzite from the underlying formations rests upon Jefferson City dolomite of Lower Ordovician age.⁵⁸ This indicates the removal of the Devonian and the Joachim, which near Providence are observed between the Kinderhook and the Jefferson City, and possibly other formations which may have been deposited in this region.

In Callaway county, the Snyder Creek shale, of early Upper Devonian age, approximately 30 to 40 feet in thickness, overlies the upper Middle Devonian Callaway limestone. The Kinderhook rests upon the Snyder Creek in some places and in others on the Callaway. Locally in Warren county the Kinderhook is observed immediately overlying the Kimmswick (Middle Ordovician) limestone.

It is evident that the unconformity at the base of the Kinderhook in central Missouri is one of considerable importance. The formations underlying the Mississippian vary in age from early Upper Devonian to Lower Ordovician.

SYLAMORE SANDSTONE

The Sylamore sandstone of central Missouri is so inconspicuous an horizon throughout most of its extent that it is hardly to be recognized as a separate geologic formation. None the less it is very distinct in its lithologic and faunal characters from other deposits in the region, is very widespread and has stratigraphic relations unlike those of the Chouteau. It is probably separated from the Chouteau by disconformity.

Distribution and thickness. The Sylamore is an exceptionally thin and persistent stratum throughout the western portion of the central Missouri region. It is observed in most of the

sections which show the base of the Mississippian, its thickness in this district ranging from 1 inch to 1 foot. East of Boone county exposures of the formation are not abundant but the thickness observed is greater. It is 3 feet thick in the vicinity of Sandy Hook,⁵⁸ Moniteau county, and to the south. In this region it contains numerous pebbles of chert and quartzite. In Callaway county, though the Chouteau limestone is very thin and locally wanting, the Sylamore is well developed in a number of places. Typical exposures are observed on Dark Hollow creek, 3 miles southeast of Fulton, from which Branson and Greger* have collected an interesting invertebrate fauna. The sandstone at these outcrops is massive and almost colorless for the greater part, with a peculiar watery-green mottling, its thickness ranging from a few inches to 3 feet. At the localities visited by the writer in Montgomery county the base of the Kinderhook is not exposed. Connolly¹³ has reported this sandstone on Smith's Branch of Clear Fork creek, 4 to 6 inches thick, and Branson⁵⁰ indicates that the formation is nearly 60 feet at certain places in the county. On streams in southeastern Montgomery county the Sylamore is thin. Southwest of Warrenton, Warren county, where the Chouteau rests on Ordovician limestone, the sandstone is absent, but not far distant it is 4 to 5 feet thick. Broadhead⁶ observed 40 feet of Sylamore at one locality in this county. In the bluffs of Peruque creek, between Warren and St. Charles counties, there is an exposure of 6½ feet of white sandstone at the horizon of the Sylamore.

Lithologic character. The Sylamore sandstone possesses such peculiar and distinctive lithologic characters that on this basis alone it may, in general, be recognized without difficulty. With observation on its stratigraphic position and the aid of occasional fossils it may be followed with assuredness over a considerable area.

The color of the Sylamore is commonly a sort of bluish, watery green. In many localities, however, it is an almost limpid white and in some exposures it appears as a massive, white, sugary rock with numerous irregular mottlings of green. With the oxidation of ferruginous matter, exposed surfaces take on a red or yellowish brown color. In the mottled varieties the weathered rock has a beautifully variegated red and white color.

*E. B. Branson, personal communication.

The sandstone is rather coarse-grained. The grains consist of rounded fragments of translucent or perfectly clear quartz, very closely resembling the sand grains of the St. Peter. They are cemented by lime carbonate which is in most cases in sufficient quantity to give the formation a more or less calcareous aspect. Locally where there is insufficient cement, the rock is a soft, friable sandstone which falls into a loose sand when struck with the hammer. Well defined bedding planes are not commonly observed.

Especially characteristic of the Sylamore in certain regions is the presence of angular or rounded, more or less water-worn chert pebbles, and nodules of light-gray or black phosphatic material. The chert fragments vary in size from the dimensions of a common sand grain to pebbles of 2 inches diameter. The chert resembles that of the Ordovician, varying in color from milky white or pink to bluish black. The chert is not infrequently agatized. The phosphatic nodules vary in size from 1/8 to 1 inch or more in diameter. They are not so common in the Sylamore sandstone of central Missouri as in the deposits of similar character in northern Arkansas.

On weathering the Sylamore tends to develop smooth, rounded surfaces, or it may have a somewhat nodular, uneven appearance. The rounded outcrops are not infrequently covered with a mat of gray green mosses and lichens. The soft calcareous, somewhat shaly facies of the formation weathers readily and appears as a re-entrant in exposures that show the formations above and below.

Paleontologic character. On account of the coarse-textured, porous character of the Sylamore sandstone, fossil shells are rare. Fish teeth, most of which belong to a single species, *Ptyctodus calceolus* N. & W., are not uncommon, however, though they are always more or less water worn. This wearing may be due to the grinding action of the sand grains in the formation under the pounding of waves on an ancient sea beach, or it may be partly due, as Branson^{5b} has suggested, to erosion in which the teeth were removed from a Devonian shale. It hardly seems likely that all the *Ptyctodus* teeth of the Sylamore are Devonian fossils secondarily found in a Kinderhook deposit, for they are very numerous and contain few or practically no other of the Devonian fishes. *Ptyctodus* lived in the lower Mississippian Glen Park limestone of southeastern Missouri.

In the Sylamore sandstone at Providence, a specimen identified by Branson⁵ as *Dipterus digitatus* Eastman has been collected. It is possible that this specimen was derived by erosion from Devonian beds. Coprolitic forms are not uncommon at certain localities.

Branson and Greger have collected a fauna of invertebrates from the Sylamore sandstone on Dark Hollow creek, Callaway county. The fauna is not yet described but it contains a number of elements that indicate Mississippian age.

Correlation. The most striking feature concerning the Sylamore sandstone is the coarse, well rounded character of its quartz grains. Sandstone of this type is entirely foreign to the general character of the lower Mississippian, and in itself constitutes a feature of importance in the correlation of the formation. It contains water worn chert pebbles and nodules of phosphatic material which clearly indicate a preceding erosion interval. The sand was in all probability derived from the much older St. Peter sandstone, which must have had extensive outcrops in the Ozark region prior to the deposition of the Kinderhook. The Sylamore sandstone may, therefore, represent the more or less cleanly washed debris of the old pre-Kinderhook land area which contained weathered material from the St. Peter and other formations.

The Sylamore sandstone lies with well marked unconformity on formations of the older Paleozoic. As the basal deposit of the advancing Kinderhook sea in the central Missouri region, it is possible that it does not represent entirely contemporaneous deposition throughout its extent. However there is probably not a great difference in the time of formation of the Sylamore in different localities, or between the Sylamore and the various deposits related to it. In lithologic character and content of *Ptyctodus calceolus* the Sylamore of central Missouri corresponds more or less closely to the Sylamore of southwestern Missouri and northern Arkansas, the Bushberg sandstone of southeastern Missouri and the Hardin sandstone of Tennessee.

CHOUTEAU LIMESTONE

The fossiliferous Chouteau limestone of central Missouri is one of the most characteristic and distinctive formations of the entire Kinderhook group. It constitutes a lithologic unit very readily recognized throughout the region in which it is developed,

and contains an abundant fauna which with modifications is known very widely in the Mississippi valley basin. For these reasons Broadhead^{7a} and later Williams⁷⁵ thought the name Chouteau would be preferable to Kinderhook as a name for the group.

Distribution and thickness. The Chouteau limestone is best developed and reaches its maximum thickness in the west portion of the central Missouri district. Excellent sections are found in the bluffs of Missouri river in Howard county, north of Lisbon, on the opposite side of the river in Saline county, and for a number of miles on both sides of the river in Boone and Moniteau counties southeast of Providence. Good outcrops are also found along a number of the tributaries of the Missouri in these counties, especially on Blackwater river and Fish creek, Saline county, and Moniteau creek in Cooper county, and on Muddy creek in Pettis county. There are a number of quarries in the Chouteau in southwestern Cooper county and near Sedalia. East of Boone county the Chouteau limestone crops out in a very narrow discontinuous band at a distance of 5 to 25 miles north of Missouri river. Detailed examination has not been made in this region but the Chouteau is known to be very thin and in some places, as on Stinson creek, southeast of Fulton, it is absent. A number of the small tributaries of Loutre river in Montgomery county and Charrette and Peruque creeks in Warren county contain exposures of the formation.

The maximum observed thickness of the Chouteau limestone is slightly more than 55 feet, measured in the bluffs of the Missouri in western Howard county. The formation rarely exceeds 40 feet in thickness and in the eastern portion of its extent is generally less than 10 feet thick.

Lithologic character. The Chouteau limestone is a light bluish gray to rather dark drab rock, very compact, dense, and fine-grained. It is hard but quite brittle, and breaks with a sharply conchoidal fracture. Some varieties are so brittle that the broken fragments are not unlike fragments of splintered glass. The Chouteau is usually found in thin, rather uneven nodular layers about 2 to 4 inches in thickness, separated by dark shaly partings. This thin-layered limestone is in many cases interbedded with more massive, slightly magnesian limestone. Irregular calcite fillings and veins are common in the Chouteau. Transparent crystalline calcite also fills the fossils in many cases, and in breaking the rock the fossils are fractured

along the cleavage planes of the calcite. For this reason it is sometimes difficult to obtain good fossils. At various horizons in the Chouteau there are layers of chert nodules, varying in thickness from 1 to 4 inches, but never reaching the size of the chert nodules in the overlying Burlington limestone. When freshly broken the chert is commonly bluish black in color with a grayish white outer rim.

On weathering the color of the Chouteau limestone changes to ashy or yellowish gray, or nearly white. The alteration is superficial, however, only the very thinnest surface shell being affected. The shaly layers weather more rapidly than the compact limestone which tends to break along irregular, uneven joints, giving the exposure a fragmental, nodular or shelly appearance. Not uncommonly the thin-bedded Chouteau weathers in sloping terraces which end abruptly against the vertical walls of the superjacent Sedalia limestone. The fossil remains in the limestone are often well preserved on weathered surfaces.

Stratigraphy. At Chouteau Springs, Sec. 16, T. 38 N., R. 18 W., near Lamine river, Cooper county, the type locality of the Chouteau limestone, Swallow^{51c} indicates a thickness of 20 feet for the Chouteau, as shown in the following section:

(11) Section at Chouteau Springs, Cooper County (after Swallow)

		Thickness Feet. Inches.	
(Pennsylvanian)			
(Cherokee)			
4.	Sandstone, ferruginous.	4	
(Mississippian)			
(Osage group)			
Encrinital (Burlington) limestone			
3.	Limestone, coarse, crystalline, brown, white or gray, crinoidal.	105	
Upper Chouteau (Sedalia) limestone			
2.	Limestone, brownish-gray, earthy, silico-magnesian, in heavy beds which contain masses of calcite.	30	
(Kinderhook group)			
Lower Chouteau (Chouteau) limestone			
1.	Limestone, blue or gray, compact, irregularly stratified in thin beds with characteristic fossils.	20	

Exposures are now too poor to permit advantageous study of the formation at Swallow's locality, but at other places not far distant the Chouteau is admirably exposed. One of these, specially mentioned by Swallow, is on Lamine river near Marston's bridge Sec. 4, T. 46 N., R. 19 W. At this place there is now a large quarry operated by the Missouri, Kansas and Texas Railway, the station, which is $2\frac{1}{2}$ miles north of Clifton

City on the main line of the railroad, being known as Sweeney. The quarry at Sweeney has been worked more than 250 feet into the hill and a rock face 120 feet in height and more than 500 feet in width is exposed. A section exposing the complete thickness of the Chouteau was measured as follows:

(12) Section in Quarry of M., K. & T. R. R. at Sweeney, Sec. 4, T. 46 N., R. 19 W.'

2 1-2 Miles Northeast of Clifton City, Cooper County

		Thickness	
		Feet.	Inches.
Mississippian			
Osage group			
Burlington limestone (Lower)			
11.	Limestone, bluish-gray, coarse crystalline, crinoidal very massively bedded.....	35	
Sedalia limestone			
10.	Limestone, light blue, magnesian, fine-grained, very massive. Chert in bands.....	43	6
<i>Disconformity ?</i>			
Kinderhook group			
Chouteau limestone			
9.	Limestone bluish drab, slightly mottled, compact, with sharply conchoidal fracture. Beds thin, nodular, separated by wavy shale partings.....	2	6
8.	Limestone, drab, fine granular, fracture subconchoidal, beds rather massive. Slightly magnesian.....	3	3
7.	Limestone, bluish gray, compact, with sharply conchoidal fracture, with thin nodular beds. Chert in discontinuous bands. Persistent shale seam 3 ft. 9 in. from base.....	8	9
6.	Limestone, light grayish brown, fine granular, mottled with small elongate patches of dark bluish gray, probably organic in origin. Chert seam at top.....	1	7
5.	Limestone brownish drab, darker than above, dense, compact, with sharply conchoidal fracture. Thin uneven layers with wavy shale partings. Occasional calcite veins and fillings.....	1	5
4.	Limestone, brownish gray, fine-grained, dense, rather massively bedded. Persistent chert band at top.....	2	8
3.	Limestone, light buff gray, fine-grained, characterized by rather uniform, even beds, 2 to 6 inches in thickness which are separated by thin shale partings. Persistent prominent shale bands at top and bottom.....	5	6
Total.....		25	8
Sylamore sandstone			
2.	Sandstone, light green, calcareous, shaly, rather uniform texture and persistent.....	2-5	
Devonian			
Cooper limestone			
1.	Limestone, brownish drab, compact, dense, with sharply conchoidal fracture, massive, A lighter, more dove-colored rock than the Chouteau limestone. Exposed...	19	

The total thickness of the Chouteau limestone at Sweeney is 25 feet 8 inches. The exposure affords an excellent opportunity to study the lithologic zones in the formation and to observe the relation of the Chouteau to the beds above and below. Fossils

are numerous at various horizons and detailed collections indicate the range and distribution of the fauna within the formation.*

In the vicinity of Sedalia, 15 miles southwest of Sweeney, there are quarries in the Chouteau limestone. A section measured a short distance north of Sedalia on the Georgetown road shows the upper part of the Chouteau with the same lithologic divisions recognized at Sweeney.

(13) Section on Georgetown Road, 1 Mile North of Sedalia, Pettis County

		Thickness	
		Feet.	Inches.
	Residual clay and soil.....	3	
Mississippian			
Osage group			
Sedalia limestone			
	5. Dolomite, light blue, to yellow, siliceous, even textured, very massive, occasional calcite geodes and irregular chert nodules and layers.....	15	
	4. Limestone, light bluish, fine granular, massive, showing a slight color mottling. Chert bands 2 to 3 inches thick at top.....	3	2
	<i>Disconformity?</i>		
Kinderhook group			
Chouteau limestone			
	3. Limestone, light bluish drab, dense, compact, nodular, with thin shaly seams. Calcite veins and cavity fillings. Fossiliferous.	2	1
	2. Limestone, bluish drab, mottled with dark linear blotches, fine granular, slightly magnesian, with subconchoidal fracture. Thin chert seam at top.....	3	4
	1. Limestone, dark bluish drab, very dense, compact, with sharply conchoidal fracture, nodular layers with wavy shale partings. Exposed.....	1	

In the other direction from Chouteau Springs, in Howard county, on the east side of Missouri river, is found the most northwesterly exposure of the Chouteau limestone which is known. A rather sharp, narrow anticline, crossing Saline and Howard counties in a northeast-southwest direction, brings to view almost the entire thickness of the Chouteau. A section measured $1\frac{1}{2}$ miles north of Lisbon (Sec. 26, T. 50 N., R. 18 W.) is as follows:

*In his section measured at this same place in the bluffs of Lamine, Swallow indicated the presence of both the Lithographic (Louisiana) limestone "gray, buff or blue, compact strata, 30 ft.," and the Vermicular (Hannibal) shale, which he described as "impure yellowish, silicomagnesian limestone, 50 ft.," in thickness. He did not indicate the presence of the Chouteau limestone associated with these beds, and it seems evident that notwithstanding the typical character of the exposure at Sweeney, he did not recognize the Chouteau.

(14) Section on the Sanford Tippet Farm, North of Lisbon, Howard County. Sec. 12,
T. 50 N., R. 18 W.

		Thickness	
		Feet.	Inches.
Mississippian			
Osage group			
Burlington limestone (Lower)			
13.	Limestone, gray, coarse crystalline, crinoidal, massive (partly concealed)	30	
Sedalia limestone			
12.	Limestone, light brownish to bluish gray, dolomitic, fine granular, beds from 6 inches to 5 feet in thickness, tending to weather along joints obliquely inclined to the surface. Calcite geodes common	27	
<i>Disconformity ?</i>			
Kinderhook group			
Chouteau limestone			
11.	Limestone bluish drab, dense, compact, breaking with sharply conchoidal fracture, the weathered surface appearing shelly and fragmental. Chert in nodules and layers.	6	3
10.	Limestone, light brownish to drab gray, granular in texture, uniform, but showing a fine color mottling of light and dark blotches elongate parallel to bedding. Massive	2	2
9.	Limestone, light brown or drab, impure, non-crystalline, somewhat irregularly bedded, weathering in uneven, shelly fragments.	2	
8.	Limestone, bluish drab, compact, with sharply conchoidal fracture, in nodular layers, alternating with light brown, granular, magnesian limestone. Calcite geodes. A chert horizon at top	6	1
7.	Limestone, light brownish gray, magnesian, fine-grained, rather uniform in texture and color. Beds 6 to 8 inches in thickness. Calcite geodes and chert.	7	6
6.	Limestone, dark bluish drab, very dense, compact, with sharply conchoidal fracture, in nodular layers, with thin intercalated bands of granular, magnesian limestone.	4	6
5.	Concealed.	6	5
4.	Limestone, light brownish gray or drab, fine granular, argillaceous, a single massive ledge. Contains small calcite geodes and much chert in lower part.	9	6
3.	Limestone, drab, weathering yellow, dense, with sharply conchoidal fracture, thin and irregularly bedded. Calcite fillings and chert.	6	
2.	Limestone like above, but massive, weathering in smooth faces along joints obliquely inclined to the bedding.	5	
Total		55	5
1.	Covered to level of Missouri River flood plain.	20	

The total thickness of the beds here referred to the Chouteau limestone is 55 feet, nearly twice the thickness observed in southern Cooper county. The lower beds in this section are not well exposed and no fossils were obtained from them. Though they are not entirely similar to the typical Chouteau limestone which has been described, they do not resemble the Devonian which has been observed in this region.

The Chouteau dips beneath the level of Missouri river a short distance south of the exposure described in the last sec-

tion and reappears east of Huntsdale, Boone county. At Providence, the entire thickness of the Chouteau is well exposed in the river bluffs. The section, which has been known for many years, is as follows:

(15) Section at Providence, Boone County		Thickness Feet, Inches.	
Mississippian			
Osage group			
Burlington limestone (Lower)			
11.	Limestone, light gray to buff, coarse crystalline, crinoidal, massive, with stylolites.....	20	
Sedalia limestone			
10.	Limestone, bluish to yellowish gray, silico-magnesian, fine-grained, uniform in texture, very massive. Dis-seminated calcite fillings and small masses of pyrite...	21	6
<i>Disconformity ?</i>			
Kinderhook group			
Chouteau limestone			
9.	Limestone, brownish blue, fine-grained, compact, in thin, irregular, nodular beds with shale partings. Weathers with very shelly appearance. Chert band at base.....	13	
8.	Limestone, light brownish gray, fine-grained, slightly magnesian, finely mottled with minute, elongate dark blotches. Weathers in scaly fragments. Calcite geodes common.....	5	4
7.	Limestone, bluish drab, fine-grained, compact, in thin, nodular beds with shale partings. Weathers with shelly appearance. Chert band at base.....	3	11
6.	Limestone, yellowish blue, medium-grained, beds more massive. Weathers to brownish color.....	7	6
5.	Limestone, dark drab, compact, dense, with sharply conchoidal fracture, in thin, nodular layers. Grades into overlying division without sharp boundary.....		10
4.	Limestone, light drab, rather uniform in color and texture, fine-grained, with subconchoidal fracture. Massive.....	4	
3.	Limestone, dark bluish drab, irregularly mottled, fine-grained, compact, thin bedded. Weathers in shelly, uneven fragments.....	8	2
Total.....		42	9
<i>Disconformity ?</i>			
Sylamore sandstone			
2.	Sandstone, green, calcareous, rather soft.....	3	4
<i>Unconformity</i>			
Devonian			
Cooper limestone			
1.	Limestone, dark bluish drab, hard, brittle, dense. With slightly reddish cast unlike the Chouteau limestone. (Forms quarry floor.)		

The total thickness of the Chouteau at Providence is 42 feet 9 inches, approaching that observed in Howard county. So far as this outcrop shows, the Chouteau seems to be conformable on the subjacent Sylamore sandstone and it is not separated by an apparent break from the overlying Sedalia limestone, but in other localities there is evidence of a break in deposition both above and below the formation.

Exposures of the Chouteau limestone are excellent and almost continuous for a number of miles southeast of Providence. At Easley, three miles below Providence, there is a large quarry in the river bluff which has been used to supply stone for riprapping along the Missouri. This quarry exposes all of the Chouteau and Sedalia and more than 80 feet of the Burlington limestone. The section shows to advantage the character of the Chouteau in its fresh, unweathered condition, the same zones which were observed at Providence being also noted here.

(16) Section at Easley, Boone County

		Thickness	
		Feet.	Inches.
<i>Mississippian</i>			
Osage group			
Burlington limestone (Lower)			
11.	Limestone, light buff to bluish gray, medium- to coarse-grained, very massive, crinoidal. Coarse stylolites at intervals of 8 inches to 2 feet. Chert in lenses and bands at various horizons.	83	
Sedalia limestone			
10.	Limestone, light bluish gray, weathering to brownish yellow, dolomitic, siliceous, fine-grained, with subconchoidal fracture, very massively bedded and uniform in texture. Chert in thin bands.	22	
<i>Disconformity ?</i>			
<i>Kinderhook group</i>			
Chouteau limestone			
9.	Limestone, light bluish gray, dense, compact, in nodular layers with thin shale partings. Finely and irregularly mottled. Small calcite geodes, chert band at base. Weathers to very shelly, fragmental zone.	11	2
8.	Limestone, light brownish gray, fine-grained, mottled with fine dark blotches; a single massive ledge. Weathers along joints but not shelly.	3	4
7.	Limestone, dark bluish drab, compact, fine-grained, with sharply conchoidal fracture, beds thin and nodular, with shaly partings. Persistent band of black and white chert at base. Finely mottled with small dark blotches. Weathers to shelly, fragmental zone.	3	8
6.	Limestone like above but massive and uniform in character. Chert nodules in a narrow zone at middle of bed. On weathered surface it appears as two subequal massive beds of brownish gray limestone.	7	7
5.	Limestone, dark bluish drab, fine-grained, compact, nodular bedded. Grades into the overlying bed without sharp line of division.	1	
4.	Limestone, light drab, fine-grained, dense, with subconchoidal fracture, very massive and uniform in character. Chert nodules in upper part. On weathered surface appears as three beds.	5	4
3.	Limestone, dark bluish drab, irregularly mottled with dark blue, fine-grained, compact; beds thin, nodular with shale partings. On weathered surface appears as thin bedded, rather shelly zone.	8	10
Total.		40	11
<i>Disconformity ?</i>			
Sylamore sandstone			
2.	Sandstone, light bluish green, with fine, irregular mottling of slightly darker green, fine-grained, soft, calcareous	5-6	

<i>Unconformity</i>	Thickness
Devonian	Feet. Inches.
Cooper limestone	
1. Limestone, bluish drab, very compact, dense, with sharply conchoidal fracture. Very massively bedded. Slightly different in color and texture from the Chouteau	8

The total thickness of the Chouteau at Easley is 41 feet, approximately the same as measured at Providence. The persistence of the individual lithologic divisions which are readily distinguishable in the weathered as well as the unweathered exposures, indicates the close similarity of the two sections.

The Chouteau divisions have been traced at least six miles farther southeast in the bluffs on the north side of Missouri river and a partial section of the Chouteau at Wilton measured by H. M. Scott⁴¹ indicates the persistence of the subdivisions.

(17) Section Southeast of Wilton, Boone County (after Scott)

	Thickness	
	Feet.	Inches.
Kinderhook group (Osage)		
"Upper Chouteau limestone" (Sedalia)		
10. Limestone, blue weathering to yellow, arenaceous, massively bedded, non-fossiliferous	17	10
(Kinderhook group)		
"Lower Chouteau limestone" (Chouteau)		
9. Limestone, blue, fine-grained, in thin irregular layers, with alternating shale partings. Numerous small calcite fillings and veins	6	9
8. Limestone, yellowish gray, more coarsely crystalline, massively bedded	1	7
7. Limestone, bluish drab, in thin, irregular layers. Like 9 . . .	1	10
6. Limestone, yellowish gray, massively bedded. Like 8	3	
5. Limestone, blue, fine-grained, in thin, irregular beds with shale partings. Like 9		10
Covered to river.		

The lithologic units in this section are the same as those in the sections at Easley and Providence which have been noted, but they are somewhat thinner.

On the south side of Missouri river in Moniteau county, the Chouteau is well exposed at a number of places. A complete section of the formation is found southeast of Sandy Hook, sec. 13, T. 46 N., R. 14 W., its thickness here amounting to 40 feet. Farther east the Chouteau diminishes in thickness with remarkable rapidity. Van Horn⁵⁸ has described places in Moniteau county where Burlington limestone rests unconformably on the Jefferson City dolomite.

The Chouteau limestone is not present in sections which have been studied near Fulton, Callaway county, and east of Mineola, Montgomery county, but at a number of intervening localities there are thin exposures of the Chouteau which exhibit all the typical lithologic and faunal characters of the formation.

A section on Clear Fork, southwest of Montgomery City, sec. 2, T. 48 N., R. 6 W., was examined by the writer. Observations in the vicinity indicate that the total thickness of the Chouteau is not more than 12 or 15 feet. The disconformity between the Chouteau and the Sedalia, shown here and at other places is of interest. The most complete section of the Chouteau in Warren county is reported by Connolly,¹³ southwest of Warrenton.

(18) Section on Clear Fork, Near Montgomery City, Montgomery County. NW. 1-4,
Sec. 2, T. 48 N., R. 6 W.

Mississippian Osage group		Thickness	
		Feet.	Inches.
	Burlington limestone (Lower)		
	5. Limestone, bluish-gray to white, pure, rather coarse-grained, hard, crystalline, crinoidal, massive.	6	6
	4. Limestone, light bluish to brownish gray, medium-grained, hard, very massive, crystalline.	11	
	Sedalia limestone		
	3. Limestone, light yellowish, fine-grained, rather soft, mostly compact but locally very porous; weathered rock breaks into fine dust when struck with a hammer. Massive, tends to form re-entrant in cliff. Band of nodular chert near top.	4	6
	2. Limestone, grayish brown, fine-grained, ferruginous, magnesian, massive, lower surface uneven.	3-4	
	<i>Disconformity ?</i>		
	Chouteau limestone.		
	1. Limestone, bluish gray to drab, very compact, dense, hard, brittle, breaking with sharply conchoidal fracture. thin-bedded, with intercalated bands of slightly brown magnesian granular limestone. Calcite veins and fillings. Upper surface irregular to the extent of 1 foot indicating erosion interval. (Exposed).	7-8	

(19) Section Southwest of Warrenton, Warren County (after Connolly)

Osage group		Thickness	
		Feet.	Inches.
	Burlington limestone (Lower)		
	7. Limestone, gray, crinoidal, with typical characters.		
	"Kinderhook group" (Osage)		
	"Upper Chouteau limestone" (Sedalia)		
	6. Limestone, yellow, argillaceous, fine-grained, with thin veins of calcite, thin bedded, non-fossiliferous. Grades imperceptibly into the overlying Burlington limestone.	10	6
	5. Limestone, yellowish gray, fairly compact, sparsely fossiliferous. Can be split easily along definite bedding planes. ...	2	
	<i>(Disconformity ?)</i>		
	(Kinderhook group)		
	"Lower Chouteau limestone" (Chouteau)		
	4. Limestone, bluish gray, compact, brittle, sparsely fossiliferous. Breaks with sharply conchoidal fracture giving jagged splinters almost like broken glass. 1 ft. 8 in. from top there is a cherty layer, with large nodular dark gray chert. Calcite in veins and filling irregular cavities, abundant.	3	
	3. Limestone, light yellowish gray, arenaceous or argillaceous, not so brittle as overlying bed. Large chert nodules, light to dark gray. Not very fossiliferous.	5	
	2. Limestone, dark gray, compact, brittle, without much chert.	2	
	1. Limestone, light buff to gray, argillaceous, non-cherty, fossiliferous.	3	
	Devonian limestone		

On Dry Fork of Charette creek, $2\frac{1}{2}$ miles south of Warrenton, the Chouteau rests on the Kimmswick limestone, containing such fossils as *Bumastus*, *Rafinesquina*, etc. Southeast of Warrenton, the Chouteau rests on a shale, probably the Maquoketa. A section measured 2 miles southeast of Truesdale, is as follows:

(20) Section on Little Charette Creek, 1 1-2 Miles Southeast of Truesdale, Warren County		Thickness	
		Fect.	Inches.
Mississippian			
Osage group			
	Burlington limestone (Lower)		
	12. Limestone, light gray and brown, medium- to coarse-grained, highly crystalline, crinoidal, very massive. The beds are folded gently but in narrow irregular belts. Thickness not measured. Approximately	50	
	11. Covered interval.	?	
	<i>Disconformity?</i>		
Kinderhook group.			
	Chouteau limestone		
	10. Limestone, drab gray to blue, somewhat earthy, in thin nodular beds, 1 to 2 inches thick, with shale partings. Small calcite geodes and pyrite concretions. A few small fossils.	10	
	<i>Disconformity?</i>		
	Sylamore sandstone		
	9. Sandstone, yellowish gray to green, fine-grained, thinly laminated. Contains dark blue, sandy concretions. No fossils.		12-18
	<i>Unconformity</i>		
	Maquoketa shale?		
	8. Sandstone, yellow to brown, in massive beds, upper part horizontally laminated, lower part cross-bedded. Becomes soft on weathering.	3	
	7. Shale, yellow, sandy, rather hard.	2	
	6. Sandstone, yellow, medium-grained, massive, becomes very soft on weathering.	1	6
	5. Shale, blue or yellow, sandy, thin bedded with thin sandstone bands.	6	6
	4. Shale, blue, clayey, with thinly laminated bands of hard sandstone which stand in relief on weathered exposure.	4	6
	3. Shale, brownish drab. Argillaceous.	4	
	2. Covered.	?	
	Kimmswick limestone.		
	1. Limestone, drab gray, medium- to fine-grained, hard compact, subcrystalline, fossiliferous.	11	

Paleontologic character. The fauna of the Chouteau limestone is one of unusual interest. The fossils are generally well preserved; the number of species is large and the different invertebrate phyla are all fairly well represented. Though parts of the fauna are clearly related to Devonian ancestors, Mississippian elements are strongly developed. There are many distinctive forms which aid in separating the Chouteau from certain other Kinderhook deposits and in distinguishing the Chouteau from overlying Mississippian beds. A large part of the central



A. Burlington limestone at the quarry of the Hannibal Lime Company, Hannibal.



B. Lower Burlington limestone, Houston's Quarry, Hannibal.

Missouri Chouteau fauna is found in equivalent beds in other parts of the state, in western Illinois and in Iowa, and there are well-defined connections with distant regions.

Study of the typical Chouteau limestone of west central Missouri shows the presence of four horizons or zones in which the fossils are abundant, the intervening strata being nearly barren. Fairly large collections made at Sweeney indicate the vertical distribution of a number of species, but it is certain, of course, that the data are incomplete.

Faunal Table VII.—Fauna of the Chouteau Limestone at Sweeney, Cooper County¹

Zones	1	2	3	4
<i>Corals</i>				
Cyathaxonia tantilla (Miller).....	x	x	x	—
Zaphrentis tenella Miller.....	—	x	x	x
Amplexus blairi Miller.....	—	x	x	—
Amplexus corniculus Miller ?.....	—	x	—	—
Amplexus sp.	—	x	—	—
Monilopora sp.	x	x	x	—
<i>Worms</i>				
Spirorbis blairi Miller.....	—	x	—	x
Enchostoma n. sp.	—	—	—	x
<i>Blastoids</i>				
Schizoblastus roemeri (Shumard).....	—	—	—	x
Schizoblastus sampsoni (Hambach).....	—	—	—	x
<i>Crinoids</i>				
Actinocrinus arrosus (Miller).....	—	—	x	—
Platycrinus aequiternus Miller.....	—	—	x	—
Platycrinus sp.	—	x	—	—
<i>Bryozoans</i>				
Leioclema sp.	—	x	x	—
Fenestella sp.	—	x	x	x
Fenestella sp.	—	x	x	—
Fenestella sp.	—	x	x	—
Fenestella sp.	—	x	—	—
Pinnatopora sp.	—	—	—	x
Rhombopora sp.	x	x	x	x
Rhombopora sp.	x	x	—	—
Rhombopora sp.	—	x	—	—
Cystodictya sp.	x	x	x	x
<i>Brachiopods</i>				
Orbiculoidea sp.	—	—	x	—
Leptaena analoga (Phillips).....	—	x	x	x
Streptorhynchus tenuicostatum Weller.....	—	—	x	cf.
Chonetes burlingtonensis Weller.....	—	x	—	x

¹The zones of the Sweeney section represent the lithologic divisions of the section (see p. 85 above) as follows: Zone 1—Bed 3, Zone 2—Beds 4, 5, Zone 3—Bed 7, Zone 4—Beds 8, 9.

FAUNAL TABLE VII—Continued.

Zones	1	2	3	4
<i>Brachiopods—Cont'd</i>				
<i>Chonetes glenparkensis</i> Weller.....	—	—	x	x
<i>Chonetes logani</i> N. & P.....	—	x	x	x
<i>Chonetes</i> sp. cf. <i>C. shumardianus</i> de Koninck....	—	—	—	x
<i>Chonetes</i> sp.....	—	—	x	—
<i>Chonetes</i> sp.....	—	—	x	—
<i>Productus sedaliensis</i> Weller.....	—	—	x	x
<i>Productus arcuatus</i> Hall.....	—	—	x	—
<i>Avonia</i> ? <i>blairi</i> (Miller).....	—	—	—	x
<i>Avonia</i> sp.....	—	—	—	x
<i>Pustula concentrica</i> (Hall).....	—	—	x	x
<i>Pustula newarkensis</i> Moore.....	—	—	x	x
<i>Rhipidomella diminutiva</i> Rowley ?.....	—	x	—	—
<i>Rhipidomella tenuicostata</i> Weller.....	—	—	x	—
<i>Camarotoechia chouteauensis</i> Weller.....	—	x	x	x
<i>Camarotoechia tuta</i> (Miller).....	—	—	x	x
<i>Camarotoechia</i> sp.....	x	x	x	—
<i>Paryphorhynchus elongatum</i> Weller ?.....	x	—	—	—
<i>Shumardella missouriensis</i> (Shumard).....	—	—	x	x
<i>Shumardella obsoletus</i> (Hall).....	—	—	x	x
<i>Rhynchopora</i> sp.....	—	—	—	x
<i>Dielasma chouteauense</i> Weller.....	—	—	—	x
<i>Spiriferina subtexta</i> White.....	—	x	x	x
<i>Spirifer louisianensis</i> Rowley.....	—	—	x	x
<i>Spirifer missouriensis</i> Swallow.....	—	—	—	x
<i>Spirifer</i> sp.....	—	—	x	—
<i>Brachythyris peculiaris</i> (Shumard).....	x	—	x	x
<i>Syringothyris missouri</i> Hall & Clarke.....	—	—	x	cf.
<i>Ambocoelia parva</i> Weller.....	x	x	—	?
<i>Ambocoelia unionensis</i> Weller.....	—	x	—	—
<i>Reticularia cooperensis</i> (Swallow).....	—	—	x	x
<i>Cliothyridina tenuilineata</i> (Rowley) ?.....	x	—	x	x
<i>Composita</i> sp.....	—	—	x	—
<i>Composita</i> sp.....	—	—	x	—
<i>Pelecypods</i>				
<i>Grammysia blairi</i> Miller.....	—	—	x	—
<i>Cardiopsis</i> sp.....	—	—	—	x
<i>Parallelodon blairi</i> (M. & G.).....	—	—	x	x
<i>Parallelodon facetus</i> (M. & G.).....	x	—	—	—
<i>Schizodus trigonalis</i> (Winchell) ?.....	—	—	—	x
<i>Schizodus sedaliensis</i> M. & G.....	—	—	x	—
<i>Pterinopecten sedaliensis</i> Miller.....	—	—	x	x
<i>Pterinopecten circulus</i> (Shumard).....	—	—	—	x
<i>Pterinopecten cooperensis</i> (Shumard).....	—	x	x	x
<i>Cypricardina sulcifera</i> Winchell.....	—	—	x	x
<i>Gastropods</i>				
<i>Bellerophon blairi</i> Miller.....	—	—	—	x
<i>Bellerophon</i> sp.....	x	—	—	—
<i>Pleurotomaria sedaliensis</i> Miller.....	?	—	—	x

FAUNAL TABLE VII—Continued.

Zones	1	2	3	4
<i>Gastropods—Cont'd</i>				
Murchisonia sp.	x	—	—	—
Straparollus sp.	—	—	x	—
Loxonema tenuilineatum (Shumard).....	—	x	—	x
Loxonema sp.	—	—	x	—
Holopea blairi (Miller).....	—	—	x	—
Platyceras nasutum Miller.....	—	—	x	—
<i>Cephalopods</i>				
Orthoceras sp.	x	—	x	x
Triboloceras digonum (M. & W.).....	—	—	—	x
Muensteroceras ? osagense Swallow.....	—	—	x	—
<i>Crustaceans</i>				
Proetus sp.	—	—	—	x
Phillipsia sp.	—	—	x	x
Phillipsia sp.	—	—	—	x
Phillipsia sp.	—	—	—	x
Griffithides ? sedaliensis Vogdes ?.....	—	—	x	—
Brachymetopus armatus Vogdes.....	—	—	x	x

Of the 14 species reported in Zone 1 all of the identified forms but two occur in higher beds. *Paryphorhynchus elongatum* which is recognized with question in the lowest faunal zone at Sweeney, was found in the Chouteau limestone of Montgomery county and is present abundantly in the uppermost faunal zone of the Chouteau in northeastern Missouri.

In Zone 2 there are 28 observed species, practically all of which occur in other zones as well. *Ambocoelia unionensis*, apparently quite distinct from the associated *A. parva*, is found only at this horizon; it is typically developed in the Rockford limestone of Indiana.

Zone 3 contains 48 species, ten of which are not reported from other zones in this section. *Productus arcuatus* is a widely distributed Kinderhook fossil which is found in most of the Chouteau collections from central Missouri, in northeastern Missouri, Beds 5 and 6 at Burlington, Iowa, and according to Van Tuyl⁵⁹ in the Chapin formation of central Iowa. *Rhipidomella tenuicostata* is characteristic of the Chouteau in all parts of Missouri. While not found in southeastern Iowa, it is tentatively identified in the central part of that state. The pelecypods and gastropods that are apparently restricted to Zone 3 at Sweeney are found at many other Chouteau localities. *Muensteroceras ? osagense* is common elsewhere in the Chouteau of

central Missouri and is found in the Northview formation of southwestern Missouri.

There are 50 species identified in Zone 4, and of this number 10 were not found lower in the formation. The blastoids *Schizoblastus roemeri* and *S. sampsoni* are characteristic of the Chouteau in central and southwestern Missouri, the former being reported also from the Chapin beds of Iowa. *Avonia* ? *blairi* is common elsewhere in the central Missouri Chouteau and occurs in Bed 5 at Burlington, Iowa, and the English River sandstone of southeastern Iowa. *Dielasma chouteauense* is a typical Chouteau species found in northeastern, central and southwestern Missouri but not in Iowa. The cephalopod *Triboloceras digonum* has a similar distribution but occurs also in the Rockford limestone.

Typical Chouteau species having a range through two or more of the zones designated are *Zaphrentis tenella*, *Amplexus blairi*, *Chonetes glenparkensis*, *Productus sedaliensis*, *Pustula concentrica*, *Camarotoechia chouteauensis*, *C. tuta*, *Shumardella missouriensis*, *S. obsolens*, *Brachythyris peculiaris*, *Syringothyris missouri*, *Reticularia cooperensis*, *Pernopecten cooperensis* and *Parallelodon blairi*.

Fossil collections from the Chouteau limestone in other parts of central Missouri are shown in Table VIII. Since previous workers have classed with the Chouteau as here defined, the overlying silico-magnesian (Sedalia) limestone which contains a fauna distinct from the lower beds, it is not possible at present to indicate the stratigraphic position of all of the "Chouteau" species that have been described from this region. In the following table some of the species (indicated by *) reported from localities 3, 4 and 6 are believed to come from the "Upper Chouteau" or Sedalia; they have not been observed by the writer in the Chouteau as defined. A few species are included in Table VIII as belonging in the restricted Chouteau fauna of central Missouri, though not reported from the localities listed. This assignment is based on examination of the lithology of the matrix of specimens in Walker Museum and must be regarded as tentative. Species that are more or less definitely assignable to the Sedalia are recorded in the discussion of that formation (see below). It is necessary to refer a part of the composite "Chouteau" fauna to a waiting list until additional knowledge permits determination of precise stratigraphic position. This group of species is listed in Table IX.

Faunal Table VIII.—Fauna of the Chouteau Limestone in Central Missouri

Localities†	1	2	3	4	5	6
<i>Corals</i>						
Cyathaxonia tantilla (Miller).....	x	—	x	—	x	—
Cyathaxonia arcuata Weller ?.....	—	—	—	—	—	x
*Microcyclus blairi Miller.....	—	—	x	—	—	—
*Zaphrentis calycula Miller.....	—	—	x	—	—	—
Zaphrentis chouteauensis Miller.....	—	—	x	—	—	—
*Zaphrentis cliffordana E. & H.....	—	—	—	—	—	x
*Zaphrentis exigua Miller.....	—	—	x	—	—	—
Zaphrentis tenella Miller.....	x	x	x	—	x	—
Zaphrentis sp. cf. Z. wortheni Weller.....	—	—	—	—	x	—
Amplexus blairi Miller.....	x	x	x	—	x	—
Amplexus corniculus Miller.....	?	x	x	—	—	—
Amplexus sp.....	x	—	—	—	—	—
*Aulopora sp.....	—	—	x	—	—	—
Monilopora sp.....	x	—	x	—	—	—
*Syringopora harveyi White.....	—	—	x	—	—	—
*Leptopora typa Winchell.....	—	—	x	—	—	—
<i>Worms</i>						
Spirorbis blairi Miller.....	x	—	—	x	—	x
Cornulites sp.....	—	—	—	—	—	x
Enchostoma lanceolatum (Miller) ¹	—	—	—	—	—	—
Enclostoma sp.....	x	—	—	—	—	—
<i>Blastoids</i>						
Schizoblastus roemeri (Shumard).....	x	—	x	x	—	x
Schizoblastus sampsoni (Hambach).....	x	x	—	—	—	—
*Codaster blairi (M. & G.).....	—	—	x	—	—	—
<i>Crinoids</i>						
Agaricocrinus sampsoni Miller ²	—	—	—	—	—	—
Actinocrinus arrosus Miller.....	x	—	—	—	—	x
*Actinocrinus chouteauensis Miller.....	—	—	—	x	—	—
Platycrinus aequiternus Miller.....	x	—	—	—	—	—
*Platycrinus absentivus Miller.....	—	—	x	—	—	—
Platycrinus clinatus M. & G.....	—	—	x	x	—	—
*Platycrinus pettisensis M. & G.....	—	—	x	—	—	—
Platycrinus sp.....	x	x	—	—	—	x
Barycrinus meekianus (Shumard).....	—	—	x	x	—	—
*Poteriocrinus sampsoni M. & G.....	—	—	x	—	—	—
Cyathocrinus sp.....	—	—	—	—	x	—
<i>Bryozoans</i>						
Fistulipora sp.....	—	—	x	—	—	—
Batostomella sp.....	—	—	—	—	—	x
Leioclema sp.....	x	x	—	—	—	—
Fenestella sp.....	4	3	3	—	2	2
Pinnatopora sp.....	x	x	x	—	—	—
Ptilopora sp.....	—	x	x	—	—	—
Rhombopora sp.....	3	3	2	—	x	—
Streblotrypa sp.....	—	x	—	—	—	—
Cystodictya sp.....	x	x	x	—	—	—

FAUNAL TABLE VIII—Continued.

Localities†	1	2	3	4	5	6
<i>Brachiopods</i>						
<i>Lingula gorbyi</i> Miller ¹	—	—	—	—	—	—
<i>Glossina sedaliensis</i> Miller.....	—	—	x	x	—	—
<i>Orbiculoidea sampsoni</i> (Miller).....	—	—	x	—	—	—
<i>Orbiculoidea</i> sp.....	x	—	—	—	—	—
<i>Crania blairi</i> Miller.....	—	—	x	—	—	—
<i>Leptaena analoga</i> (Phillips).....	x	—	x	x	x	x
<i>Streptorhynchus tenuicostatus</i> Weller.....	x	?	—	—	—	—
<i>Schellwienella chouteauensis</i> Weller.....	—	—	—	—	—	—
<i>Schellwienella</i> sp.....	—	—	x	—	x	x
<i>Chonetes burlingtonensis</i> Weller.....	x	—	—	—	—	—
<i>Chonetes glenparkensis</i> Weller.....	x	—	—	—	—	x
<i>Chonetes logani</i> N. & P.....	x	x	—	x	x	—
<i>Chonetes</i> sp. cf. <i>C. shumardianus</i> de Kon... <i>Chonetes</i> sp.....	x 2	— —	— x	— x	— x	— —
<i>Productus arcuatus</i> Hall.....	x	—	x	x	—	x
<i>Productus sedaliensis</i> Weller.....	x	—	—	—	—	—
* <i>Productus ovatus</i> Hall.....	—	—	—	—	—	x
* <i>Productus sampsoni</i> Weller.....	—	—	—	—	—	x
<i>Avonia</i> ? <i>blairi</i> (Miller).....	x	—	x	—	x	x
<i>Avonia</i> ? sp.....	x	—	—	—	—	—
<i>Pustula concentrica</i> (Hall).....	x	x	x	x	—	—
<i>Pustula newarkensis</i> Moore.....	x	—	—	—	x	—
<i>Pustula echinata</i> Moore (Chouteau Springs) <i>Pustula</i> n. sp.....	— —	— x	— —	— —	— —	— —
<i>Rhipidomella diminutiva</i> Rowley ?.....	x	—	—	—	—	—
<i>Rhipidomella tenuicostata</i> Weller.....	x	—	x	x	—	x
<i>Rhipidomella thiemei</i> White.....	—	—	x	—	—	—
<i>Schizophoria chouteauensis</i> Weller.....	—	—	x	?	—	—
<i>Camarotoechia chouteauensis</i> Weller.....	x	x	—	—	x	—
<i>Camarotoechia tuta</i> (Miller).....	x	x	—	—	x	—
<i>Camarotoechia</i> sp.....	x	x	—	—	—	—
<i>Paryphorhynchus elongatus</i> Weller.....	?	—	—	—	—	x
<i>Shumardella missouriensis</i> (Shumard).....	x	—	x	x	x	x
<i>Shumardella obsolens</i> (Hall).....	x	—	x	x	x	x
* <i>Rhynchopora</i> ? <i>cooperensis</i> (Shumard).....	—	—	x	x	—	x
<i>Rhynchopora</i> sp.....	x	—	—	—	x	—
<i>Cranaena occidentalis</i> (Miller).....	—	—	x	—	x	—
<i>Dielasma chouteauense</i> Weller.....	x	—	x	x	x	x
<i>Spiriferina subtexta</i> White.....	x	—	—	x	—	—
* <i>Cyrtina burlingtonensis</i> Rowley.....	—	—	x	—	—	x
<i>Spirifer latior</i> Swallow.....	—	—	—	—	—	x
<i>Spirifer louisianensis</i> Rowley.....	x	?	x	x	x	—
<i>Spirifer missouriensis</i> Swallow.....	x	x	x	x	x	—
* <i>Spirifer mundulus</i> Rowley.....	—	—	x	—	—	—
* <i>Spirifer osagensis</i> Swallow.....	—	?	x	x	—	—
<i>Spirifer platynotus</i> Weller.....	—	—	—	—	x	—
<i>Spirifer</i> sp.....	x	—	—	—	x	—
<i>Brachythyris peculiaris</i> (Shumard).....	x	—	x	x	x	x
<i>Syringothyris missouri</i> Hall & Clarke.....	x	—	—	—	—	—

FAUNAL TABLE VIII—Continued.

Localities†	1	2	3	4	5	6
<i>Brachiopods—Cont'd</i>						
Syringothyris newarkensis Weller ?	—	—	—	x	x	—
Eumetria osagensis Swallow	—	—	—	x	—	—
Ambocoelia parva Weller	x	—	—	—	x	—
Ambocoelia unionensis Weller	x	—	—	—	—	—
*Ambocoelia laevicula Rowley	—	—	?	?	—	x
Reticularia cooperensis (Swallow)	x	x	x	x	x	x
*Nucleospira obesa Rowley	—	—	x	—	—	—
*Hustedia circularis Miller	—	—	—	—	—	x
*Ptychospira explicata W. & W.	—	—	x	—	—	—
*Athyris lameillosa (L'Eveille)	—	—	—	—	—	x
Cliothyridina tenuilineata (Rowley)	?	—	—	—	—	x
Cliothyridina sp.	—	—	x	x	—	—
Composita sp.	2	—	—	—	—	—
<i>Pelecypods</i>						
Promacrus nasutus Meek	—	—	x	x	—	—
Sphenotus sinuatus M. & G.	—	—	x	—	—	—
Sphenotus telamon Hall ³	—	—	—	—	—	—
Grammysia blairi Miller	x	—	x	x	x	—
Elymella missouriensis M. & G.	—	—	—	—	—	x
Cardiopsis sp.	x	—	—	—	—	—
Edmondia albersi M. & G.	—	—	—	x	x	—
Edmondia marionensis (Swallow) ³	—	—	—	—	—	—
Edmondia sedaliensis M. & G.	—	—	—	—	—	x
Edmondia sp.	—	—	—	—	x	—
Palaeoneilo sp.	—	—	x	—	—	—
Parallelodon blairi (M. & G.)	x	—	—	—	—	—
Parallelodon facetus (M. & G.)	?	—	—	x	—	x
Parallelodon sp.	—	—	—	—	x	—
Lunulicardium retrosum M. & G.	—	—	—	x	—	—
Mytilarca jessiae M. & G.	—	—	x	x	—	—
Liopteria speciosa M. & G.	—	—	x	—	—	—
*Cardinia occidentalis Swallow ?	—	—	—	x	—	—
*Cardinia occidentalis var. minor Swallow	—	—	—	x	—	—
Schizodus sedaliensis M. & G.	x	—	x	—	—	—
Schizodus trigonalis (Winchell) ?	x	—	—	—	—	—
Pterinopecten sedaliensis Miller	x	—	—	—	x	—
Pernopecten circulus (Shumard)	x	—	x	x	x	x
Pernopecten cooperensis (Shumard)	x	x	x	x	x	—
Lithophagus ? sp.	—	—	—	—	x	—
Modiolus sp.	—	—	x	—	—	—
Cypricardella eximia M. & G.	—	—	x	x	—	x
Cypricardella sp.	—	x	—	—	—	—
Cypricardina sulcifera Winchell	x	—	x	—	x	—
Cypricardia chouteauensis Swallow ³	—	—	—	—	—	—
<i>Gastropods</i>						
Bellerophon blairi Miller	x	—	—	x	—	x
Bellerophon sp.	x	—	—	—	—	—
Bucanopsis sedaliensis (M. & G.)	—	—	x	x	—	—
Pleurotomaria sedaliensis Miller	x	—	x	—	—	—

FAUNAL TABLE VIII—Continued.

Localities†	1	2	3	4	5	6
<i>Gastropods—Cont'd</i>						
Pleurotomaria sp.	—	—	x	—	—	—
Murchisonia sp.	x	—	—	—	—	—
Straparollus blairi Miller ¹	—	—	—	—	—	—
Straparollus lens Hall.	—	—	x	—	—	—
Straparollus missouriensis M. & G ¹	—	—	—	—	—	—
Straparollus sp.	x	—	x	x	—	x
Tropidodiscus cyrtolites (Hall) ³	—	—	—	—	—	—
Strophostylus bivalve (W. & W.)	—	—	x	x	—	—
Loxonema tenuilineatum (Shumard)	x	—	x	—	—	x
Loxonema sp.	x	—	—	—	—	—
Holopella bellilineata (Miller) ¹	—	—	—	—	—	—
Holopea blairi (Miller)	x	—	—	—	—	—
Platyceras haliotoides M. & W.	—	—	—	x	—	—
Platyceras nasutum Miller.	x	—	—	—	—	—
Platyceras sp.	—	—	—	—	—	x
Orthonychia lodiensis (Meek)	—	—	x	—	—	—
<i>Pteropods</i>						
Conularia blairi M. & G. ¹	—	—	—	—	—	—
Conularia sampsoni Miller ¹	—	—	—	—	—	—
<i>Cephalopods</i>						
Orthoceras chouteauense Swallow.	—	—	x	—	—	—
Orthoceras sp.	x	—	—	—	—	x
Triboloceras digonum (M. & W.)	x	—	x	x	—	?
Solenocheilus blairi Miller.	—	—	x	—	—	x
Poterioceras missouriense Miller.	—	—	x	—	x	x
Phragmoceras missouriense Miller.	—	—	—	—	—	—
Aganides jessiae M. & G.	—	—	—	—	—	—
Prodromites gorbyi (Miller)	—	—	—	—	—	—
Muensteroceras ? holmesii (Swallow)	—	—	—	—	—	—
Muensteroceras ? osagense (Swallow)	x	—	x	x	—	—
<i>Trilobites</i>						
Proetus ? placidus Vogdes.	—	—	—	—	—	—
Proetus swallowi Shumard.	—	—	—	?	—	—
Proetus sp.	x	—	—	—	x	—
Phillipsia sampsoni Vogdes.	—	—	—	x	—	—
Phillipsia sp.	3	—	—	x	x	2
Griffithides ? sedaliensis Vogdes.	?	x	x	x	x	—
Brachymetopus armatus Vogdes.	x	—	—	—	x	—
<i>Fish</i>						
Orodus sp.	—	—	x	—	—	—

†Localities: 1. Sweeney, Cooper County. 2. Four miles north of Lisbon, Howard County. 3. Bluffs on Missouri River at Providence, Boone County (faunal list compiled from identifications of collections made by the writer, specimens in Walker Museum University of Chicago, and data furnished by H. M. Scott, Master's thesis, University of Missouri). 4. Bluffs of Missouri River near Lupus, Moniteau County (compiled from collections by the writer and identifications reported by F. B. Van Horn, Geology of Moniteau County). 5. On Clear Fork, southwest of Montgomery City, Montgomery County (sec. 3, T. 48 N., R. 6 W.). 6. On Smith's Branch, south of Montgomery City, Montgomery County (sec. 13, T. 48 N., R. 6 W., collection and identifications by D. K. Greger, cited by J. P. Connolly, Master's thesis, University of Missouri).

*Species probably from the "Upper Chouteau" (Sedalia).

¹Near Sedalia, Mo.

²Chouteau Springs, Mo.

³Cooper County, Mo.

Faunal Table IX.—"Chouteau" Species of Uncertain Position

Coral

Amplexus yandelli E. & H. ?

Blastoids

Granatocrinus mutabilis Rowley

Codaster jessieae (M. & G.)

Crinoids

Rhodocrinus blairi M. & G.

Melocrinus sampsoni M. & G.

Agaricocrinus chouteauensis Miller

Agaricocrinus germanus Miller

Agaricocrinus planoconvexus Hall

Amphoracrinus jessieae M. & G.

Amphoracrinus sampsoni M. & G.

Amphoracrinus sedaliensis M. & G.

Steganocrinus hemisphericus M. & G.

Actinocrinus albersi M. & G.

Actinocrinus arrosus Miller

Actinocrinus senectus M. & G.

Actinocrinus spinulosus M. & G.

Actinocrinus trijugis Miller

Platycrinus allophylus Miller

Platycrinus annosus Miller

Platycrinus colletti Miller

Platycrinus cortinus M. & G.

Platycrinus germanus M. & G.

Platycrinus missouriensis M. & G.

Cyathocrinus blairi M. & G.

Cyathocrinus chouteauensis M. & G.

Poteriocrinus broadheadi M. & G.

Scaphiocrinus sampsoni Miller

Brachiopods

Productus parvulus Winchell

Eumetria osagensis (Swallow)

Hustedia circularis (Miller)

Pelecypods

Cardiomorpha triangulata Swallow

Chaenomya longa M. & G.

Liopteria subovata M. & G.

Aviculopecten williamsi Meek

Gastropods

Bellerophon bilabiatum W. & W.

Mourlonia sp.

Platyceras sp.

Cephalopods

Nautilus burlingtonensis (Owen)

Aganides discoidalis Smith

Prodromites ornatus Smith

Muensteroceras ? morganense (Swallow)

Pericylus ? blairi M. & G.

Trilobites

Proetus missouriensis Shumard

Proetus swallowi Shumard

Analysis of the Chouteau fauna, based on the data at hand, shows the presence of most of the important divisions of invertebrate life. Table VIII records in the formation as restricted (excluding species of doubtful position) corals 4 genera, 9 species; worms 3 genera, 4 species; blastoids 1 genus, 2 species; crinoids 5 genera, 7 species; bryozoans 9 genera; brachiopods 28 genera, 52 species; pelecypods 19 genera, 28 species; gastropods 13 genera, 22 species; cephalopods 8 genera, 10 species; trilobites 4 genera, 9 species. The molluscan element in the Chouteau fauna is an important feature more than counterbalancing the brachiopod content. Cephalopods and trilobites are important though not common. The corals are not so characteristic an element of the Chouteau as of the Sedalia limestone. Crinoids are not common in the Chouteau although stems and fragments are fairly abundant.

The fauna of the Chouteau limestone is clearly one of Mississippian affinities. Among the corals the genus *Cyathaxonia*,

described from the lower Carboniferous of Belgium and England, is not known below the Mississippian. *Zaphrentis* and *Amplexus* are long ranging genera, the former however, reaching its maximum development in the Carboniferous.

Of three genera of blastoids included in the old "Chouteau" fauna only one, *Schizoblastus* has been definitely recognized in the formation as restricted. This genus is found at the base of the Carboniferous in the British Isles, but is not known below the Mississippian.

With the exception of *Platycrinus*, which is occasionally found in the Upper Devonian, the crinoids of the Chouteau are practically restricted to the Mississippian, some occurring only in North America, others such as *Actinocrinus*, *Steganocrinus*, and *Amphoracrinus* being found in the Mountain limestone faunas of Great Britain and Belgium. *Platycrinus*, which is represented by a large number of species in the Chouteau and Sedalia limestones, is really a characteristic Mississippian genus, attaining a remarkable development in the Osage epoch.

The brachiopods are rather conservative but contain a number of new elements not observed in the Devonian. Fifteen of the brachiopod genera recognized in the Chouteau are older than the Mississippian, but they do not constitute the most important part of the fauna. A few genera, such as *Syringothyris* and *Reticularia*, which originated before Mississippian time, are really most characteristic of this period. Among the new forms in the Chouteau fauna, some of which are more or less closely related to old, possibly ancestral genera, are *Spiriferina*, *Brachythyris* and the highly characteristic *Productus* group. *Shumardella*, a rhynchonelliform shell, which is one of the most common and highly characteristic genera of the Chouteau, is restricted to the Kinderhook.

The pelecypods comprise an important and interesting portion of the Chouteau fauna. The larger number are common Devonian types which appear in the Kinderhook for the last time. They are most closely related to the Hamilton faunas of North America and the Eurasiatic province of the Old World and Weller⁶⁰, ⁷⁰ believes that a considerable portion of the Chouteau fauna is directly descended from the Devonian Hamilton faunas which retreated into a separate basin during the occupation of the northern part of the country by the Chemung faunas.

The gastropods are long ranging forms without important significance in the time correlation of the Chouteau fauna.

Among the cephalopods there are a number of very interesting features. The larger number of species belong to Devonian genera which persist into the Kinderhook, but some, *Orthoceras*, *Poterioceras* and *Phragmoceras* are ancient genera ranging into the Silurian and Ordovician. *Triboloceras*, *Solenocheilus* and *Prodromites* appear in the Kinderhook for the first time. The last named is very peculiar because of its remarkably advanced development. As Smith and Weller⁴⁸ have shown, it is one of the true ammonites. It has been compared with a genus from the lower Triassic of India with which it is apparently more closely related than to any of its contemporaries in the Mississippian.

The trilobites of the Chouteau belong mainly to the Carboniferous genera *Phillipsia*, *Griffithides* and *Brachymetopus* which were first recognized in the Carboniferous strata of Great Britain. They are well differentiated from the Devonian trilobites but do not reach the specialization observed in the later Mississippian and Pennsylvanian. A hold-over element is represented by the simple forms referred to the genus *Proetus*.

It is evident that the Chouteau fauna belongs to a new chapter in the life record. It contains many more or less Devonian elements but these became extinct or greatly modified before the close of the Kinderhook.

Correlation. The Chouteau limestone of central Missouri may be correlated directly with the Chouteau which has been described in northeastern Missouri, and Calhoun and Jersey counties, Illinois. Seventy two species, representing 80 per cent of the northeastern Missouri-Illinois Chouteau fauna, and about 70 per cent of the central Missouri Chouteau fauna, are common to these districts. Many diagnostic brachiopods, such as *Streptorhynchus tenuicostatum*, *Scheliwienella chouteauensis*, *Productus sedaliensis*, *Schizophoria chouteauensis*, *Shumardella missouriensis*, *Brachythyris peculiaris*, and *Reticularia cooperensis*, and other fossils are included in this common group. The lithologic character, peculiar bedding and the general aspect of the fauna of the Chouteau in these two districts accord closely. The thin, discontinuous character of the Chouteau in the district intervening is doubtless due to erosion preceding Osage deposition, for there is no reason to believe that the Chouteau was not continuous at one time and probably of substantially

uniform thickness. The Chouteau limestone extends an unknown distance beneath the Pennsylvanian coal-bearing rocks in Illinois, and may be connected with the Rockford goniatite limestone of Jackson county, Indiana.

Thirty-five species from the central Missouri Chouteau are found in southeastern and central Iowa and it may be concluded with small question that a large part of the Iowa Kinderhook is not only contemporaneous with the Chouteau but represents deposits in a sea directly connected with central Missouri.

The Kinderhook of southwestern Missouri, as will be noted presently, is very closely connected with the Chouteau of central Missouri. Thirty-seven species, including many diagnostic forms, are common to these regions. A comparison of the fauna of the Chouteau and the Rockford limestone is of interest, the latter having long been known on account of the remarkable number and character of its goniatites. It includes the following species:

Table X.—Fauna of the Rockford Limestone, Indiana*

<i>Corals</i>	<i>Scaphopods</i>
Amplexus rockfordensis M. & G.	Dentalium aciculatum Hall
<i>Crinoid</i>	Hyolithes aculeatus Hall, W
Synbathocrinus oweni Hall	<i>Cephalopods</i>
<i>Brachiopods</i>	Orthoceras icarum Hall
Shumardella missouriensis (Shumard), C	Orthoceras indianense Hall, B
Shumardella obsolens (Hall), C	Dawsonoceras heterocinctum (Winchell)
Spirifer osagensis Swallow ?, C	B
Brachythyris peculiaris (Shumard), C	Dawsonoceras whitei (Winchell), B
Brachythyris semiplicata (Hall)	Stroboceras trisulcatum (M. & W.), W
<i>Pelecypods</i>	Triboloceras digonum (M. & W.), C
Nucula hians Hall	Oncodoceras rockfordense (M. & W.), W
Anatina leda Hall	Aganides rotatorius (de Koninck)
Cardiopsis radiata M. & W., C ² B	Prolecanites lyoni (M. & W.), W
Cypricardinia ventricosa Hall	Prodromites gorbyi (Miller), C B
<i>Gastropods</i>	Prodromites praematurus Smith & Wel-
Bellerophon lineolatus Hall, W	ler
Pleurotomaria limitaris Hall	Muensteroceras oweni (Hall), W
Pleurotomaria mitigata Hall	Muensteroceras parallelum (Hall)
Pleurotomaria vadosa Hall, W	Pericyclus ? princeps (de Koninck)
Straparollus lens Hall, C	Gyroceras gracile Hall
Straparollus spirorbis Hall, W	<i>Trilobites</i>
Soleniscus rockfordensis Miller	Proetus doris (Hall), W
Platyceras haliotoides M. & W., C	Phillipsia rockfordensis Winchell, W
Tropidodiscus cyrtolites (Hall), C	<i>Fish</i>
	Orodus multicarinatus N. & W.

*In this list species that occur in the Chouteau limestone are indicated by (C), at Burlington, Iowa, by (B), in the Waverly of Ohio, by (W).

²At Grafton, Illinois.



A. St. Joe limestone resting unconformably on the Ordovician. Mo. Pac. R. R. two miles southeast of Reeds Springs, Stone County.



B. St. Joe limestone, showing irregular bedding, near Noel, McDonald County.

The number of species in this fauna which also are found in the Chouteau is not as large as the number common to Waverly beds, but there are included some of the very characteristic Chouteau fossils. Especially significant are the peculiar specialized cephalopods *Triboloceras digonum* and *Prodromites gorbyi* which are found in both formations. *Prodromites gorbyi* is known by a few specimens only and from but three localities, the Rockford limestone, the upper Kinderhook beds at Burlington, and the Chouteau limestone of central Missouri. Three excellent specimens have been collected at Pin Hook bridge on Muddy creek, a few miles northeast of Sedalia. The occurrence of these forms must mean the contemporaneity of the containing formations within rather narrow limits. There is no satisfactory basis at all for the correlation of the Rockford limestone with the Louisiana limestone, as suggested by Kindle.⁸¹ The faunas of these formations have practically nothing in common.

Associated with the Chouteau forms in the Rockford fauna is *Aganides rotatorius*, which, while not reported elsewhere in North America, is so abundant and characteristic a species of the Tournaisian stage of the Lower Carboniferous (Dinantian) of Belgium that it is regarded as an index fossil of the horizon. Its association with species which are closely limited to the Chouteau horizon in this country, affords basis for correlation with the Tournaisian of Europe. It may also be observed that the pelecypod genus *Promacrus* occurs in the Lower Carboniferous of Belgium,—indeed, de Koninck figures a specimen which he identifies with *P. nasutus* Meek, from the Chouteau limestone.

SUMMARY

Sylamore sandstone. The Sylamore sandstone is a thin but persistent formation at the base of the Kinderhook in central Missouri. It is largely composed of rounded sand grains similar to those of the St. Peter sandstone and contains water-worn fragments of chert and quartzite derived by erosion of pre-Kinderhook rocks. The formation rests with well-defined unconformity on strata ranging in age from early Upper Devonian to Lower Ordovician. The chief faunal content of the Sylamore consists in abundant but more or less water-worn teeth of the fish *Ptyctodus calceolus*. These teeth, though common in rocks of Devonian age, are especially abundant over a large area in deposits analogous to the Sylamore sandstone in lithologic character, stratigraphic position, or both.

Chouteau limestone. The Chouteau limestone is the chief formation of the Kinderhook in central Missouri. It consists characteristically of bluish drab, hard, dense, fine-grained limestone in thin, rather uneven layers which weather in a shelly, fragmental surface. The maximum thickness of the formation, about 55 feet, is observed in the west portion of the central Missouri region, where also are the most numerous and typical exposures. The average thickness is about 35 feet and east of Boone county it is in most cases less than 10 feet. Probably due to erosion the Chouteau is discontinuous and variable in thickness in this thinned area.

The Chouteau is highly fossiliferous, the fauna consisting largely of brachiopods and mollusks, distinctly Mississippian in aspect. The fauna is fairly uniform throughout central Missouri and closely resembles the faunas observed in the Chouteau of northeastern Missouri and western Illinois. The upper Kinderhook beds at Burlington, Iowa, correspond to the Chouteau, but are probably equivalent to the upper portion rather than all of the formation. The Rockford limestone of Indiana is of Chouteau age.



A. Filled sinks in Burlington limestone, Columbia, Boone County.



B. Burlington limestone at Osceola, St. Clair County, quarry of Osceola Lime Company.

THE SOUTHWESTERN MISSOURI KINDERHOOK

INTRODUCTION

The Kinderhook of southwestern Missouri seems to correspond in lithologic character and stratigraphic succession to the Kinderhook of the northeastern part of the state; accordingly, various workers in southwestern Missouri have employed the names of the northeast Missouri formations. As will be shown, these correlations are at least in part erroneous.

Areal distribution and thickness. Outcrops of the Kinderhook are in the main confined to a strip of varying width bordering the Ozark side of the Mississippian area. A few isolated exposures are observed in St. Clair and Cedar counties, but the best sections have been obtained in southern Polk, northeastern and eastern Greene and Webster counties. The Kinderhook extends eastward into Wright county, outliers being found as far east as the Texas county line. In a southwest direction from Wright county the Kinderhook appears to decrease in thickness rapidly. Exposures in Barry and McDonald counties show the black shale which is so widely developed on the south flank of the Ozark dome. In some exposures both in southwestern Missouri and northern Arkansas strata referable to the Kinderhook appear to be wanting, and the Osage group rests directly on the subjacent Ordovician or Silurian.

The maximum thickness of the Kinderhook in southwestern Missouri is found in northeastern Greene county and adjacent parts of Webster and Polk counties. It amounts to approximately 125 feet. In most portions of the region, the group is not more than 50 or 60 feet thick.

Lithologic character. The Kinderhook of southwestern Missouri includes coarse, locally conglomeratic, sandstone; fissile, black, carbonaceous shale; medium-grained and lithographic limestone; arenaceous shale; and fine-grained, calcareous sandstone. The coarse sandstone and black shale are thin, discontinuous formations which form the patchy, basal deposit of the group. The limestone is a well defined horizon overlying the sandstone or black shale, or is observed directly overlying the older Paleozoic beds. The arenaceous, calcareous shale and very fine-grained, calcareous sandstone is the thickest forma-

tion in the Kinderhook region. In the northern part of the district a compact, rather impure, locally very fossiliferous limestone probably the equivalent of the Chouteau limestone of central Missouri is observed.

Divisions. The Kinderhook of the southwestern Missouri includes the following formations:

- Chouteau limestone
- Northview formation
- Compton limestone
- Chattanooga shale
- Sylamore sandstone

The Sylamore sandstone, named from a creek in Stone county, Arkansas,⁷⁶ was called Phelps in earlier Missouri reports.⁴²

The black shale of the southwestern Missouri Kinderhook represents the formation named Eureka shale by the Arkansas Geological Survey^{47a} from exposures at Eureka Springs, Carroll county. This name, which was formerly used also in Missouri,⁴³ was preoccupied and in 1904 Ulrich⁵⁵ proposed the name Noel shale, from the town of Noel, McDonald county, Missouri. According to later work by Ulrich^{56a}, ⁵⁷ and others¹ it seems probable that the Noel shale is the direct equivalent of the Chattanooga shale exposed in Tennessee, and the name Chattanooga shale is now in general use. Outcrops of black shale observed on James river in Greene and Christian counties, Missouri, Ulrich^{56c} designated the James River shale, but there seems no reason for regarding this shale as different from Chattanooga.

The Compton limestone is recognized from exposures beneath the Northview formation in the vicinity of Compton near the west line of Webster county. On account of its position beneath the supposed equivalent of the Hannibal formation of northeastern Missouri, Swallow^{51a} called this limestone the "Lithographic," the name formerly applied to the Louisiana limestone. He was followed in this correlation by Shumard,⁴⁴ Broadhead⁷ and Keyes.²³ Winslow⁷⁸ refers the limestone at the base of the Northview to the Louisiana, but on the basis of reports by Rowley it is noted that "the fossils bear a stronger resemblance to the Chouteau limestone." A few small outcrops of dense, drab limestone in Greene county, which probably

represent the Compton limestone, were referred by Shepard^{42b} to the Louisiana, but elsewhere the Compton is apparently included as a calcareous facies of the Northview formation and called the Hannibal limestone.^{67b}

The Northview formation was named by Weller⁶⁶ from exposures in the vicinity of Northview, Webster county, Missouri. The formation was recognized by Swallow^{51a} who correlated it with the "Vermicular sandstone and shale" (Hannibal formation) of northeastern Missouri. Other authors^{7, 45} have followed Swallow or have applied the newer name Hannibal sandstone and shale.^{9, 22, 42} As will be discussed below, the Northview formation does not appear to correspond exactly to the Hannibal formation.

The Chouteau limestone has its type locality in central Missouri, as described above. Examination of the southwest Missouri Kinderhook has not been sufficiently detailed to make certain the areal relations of the Chouteau in this region, or to fix its exact stratigraphic relations, but it appears to be present in some localities. The formation which has commonly been referred to the Chouteau limestone in southwest Missouri by authors is a yellowish, silico-magnesian limestone corresponding to the upper part only (Sedalia) of the central Missouri Chouteau limestone. It has been called the Pierson limestone, by Weller⁶⁶ and is not the equivalent of the Chouteau limestone as restricted.

Pre-Kinderhook unconformity. Nowhere in the entire Kinderhook area of southwestern Missouri is the Mississippian, as here defined, known to overlie strata younger than the Ordovician.* The formation beneath the Mississippian in most cases is the Jefferson City dolomite of lower Ordovician age, but locally various other formations underlie the Kinderhook. The absence of the Silurian and Devonian is sufficient indication of the magnitude of the erosion interval which must have preceded the advance of the Kinderhook sea on this side of Ozarkia. Whether the Devonian and Silurian sea ever occupied this portion of Missouri cannot be answered on evidence now at hand. Beds of Silurian age are found in patches in northeastern Oklahoma and northern Arkansas, and it is not improbable that the Silurian may at one time have extended across a part of southwestern Missouri. In this case, subsequent erosion has

*Beds of supposed Devonian age have been described in Greene County (Shepard ⁴²) but there is good reason to believe that these are referable to another system.

entirely removed it along the margin where the Kinderhook is exposed. That the Devonian sea ever occupied the region is open to question, unless it is proven that the black Chattanooga shale of this region and the related Sylamore sandstone belong to this period rather than the Mississippian.

The extent and importance of the unconformity at the base of the Mississippian, which is well defined also in northern Arkansas, is shown by observation of the stratigraphic divisions occurring next below the Kinderhook along the southern flank of the Ozark highland. To the west, in northeastern Oklahoma, the Mississippian rests on St. Clair (Niagaran) limestone.⁵² The Mississippian overlies the Tyner formation and Burgen (St. Peter) sandstone in parts of northwestern Arkansas and elsewhere it rests directly upon the Yellville (Lower Ordovician) limestone. Eastward the Kinderhook is found in contact with the St. Peter²⁰ sandstone, Izard (Chazyan) limestone,^{20a} and Polk Bayou (Kimmswick-Cincinnatian) limestone^{77a} of the Ordovician.

SYLAMORE SANDSTONE

The Sylamore sandstone is easily recognizable, but very thin and discontinuous. It is similar to the basal sandstone of central Missouri.

Distribution and thickness. Data concerning the distribution of the Sylamore in southwest Missouri are largely due to the work of Shepard⁴² who has studied the formation in Greene county and vicinity. Southeast of Springfield (sec. 1, T. 26 N., R. 21 W.) shafts of the Phelps mines pass through the sandstone and from this place the name "Phelps" was taken by Shepard. Its thickness here is 2 feet as shown by the following section.

21. Section at Phelps Mines, Southeast of Springfield, Greene County (after Shepard)

	Thickness	
	Feet.	Inches.
"Chouteau limestone" (Pierson)		
"Hannibal sandstone and shale" (Northview)		
"Phelps sandstone" (Sylamore)	2	
Unconformity ?		
"King limestone"		
3. Limestone, white, siliceous, seamed with lines of white calcareous material.....	14	
"First Magnesian limestone" (Jefferson City)		
2. Limestone, white, siliceous, with thick interbedded layers of dark, porous or spotted, shaly chert.....	14	
St. Peter sandstone		
1. Sandstone, white, with chert.....	3	

One mile northwest of this locality the Sylamore sandstone is found in the Pierson Creek mines where it forms the floor of the drifts. In Springfield there are deep wells which pass through the horizon of the Sylamore but in only one, so far as reported, is the sandstone observed, its thickness being 4 feet.^{42c} At the Johnson mines, 12 miles northeast of Springfield, 4 feet of Sylamore sandstone is found in one shaft and 7 feet in another 500 feet distant.^{42c} At a number of places on Pomme de Terre river in northeastern and southeastern Greene and southeastern Polk counties, the formation has been found.

The Sylamore thins rapidly in an eastward direction and as shown by sections made by Weller* in the vicinity of Northview, Webster county, the Compton limestone rests directly upon the Ordovician limestone without intervening beds. Exposures of the Kinderhook and subjacent Ordovician in the vicinity of Cedar Gap, Wright county, which have been measured by Rowley⁷⁸ also show the absence of the Sylamore sandstone. The Sylamore, 4 feet or more in thickness, was observed in somewhat disconnected outcrops along Bull creek, Christian county, between Chadwick and Sparta. A thin sandstone, possibly equivalent to the Sylamore is found at the base of the Kinderhook southeast of Reeds Springs, Stone county. On James river, in western Christian county, the Sylamore is reported in the shaft of the Delaware mines, the thickness being 4 to 6 inches.^{42c}

In northern Arkansas the Sylamore sandstone is extensively developed, its maximum thickness being much greater than observed in southwestern Missouri. The formation is known as far as the southwestern corner of the Tahlequah quadrangle⁵² in northeastern Oklahoma, its thickness amounting to 20 or 30 feet. In the Fayetteville quadrangle, northwestern Arkansas, the Sylamore outcrops in many localities, but it does not at all constitute a continuous sheet. It reaches a thickness of 75 feet on White river, just below the mouth of Hickory creek, in the southeastern portion of Benton county.¹ There are similar thicknesses of Sylamore sandstone in the quadrangle to the east, but near St. Joe, Searcy county, in Marion county, and western Stone county, Arkansas,^{20b} the sandstone is thin or absent. On Sylamore creek, eastern Stone county, the type locality of the formation, the sandstone is 20 to 40 feet thick.^{20c} It is reported in the southern portion of Izard county, 1 foot in

*Unpublished notes.

thickness^{20d} but it is not known farther east. The edge of the Mississippi embayment, which abruptly terminates the exposure of Paleozoic strata, is but a short distance to the east.

Lithologic character. As observed in southwest Missouri the Sylamore sandstone has the same peculiar lithologic features which have been described in the central part of the state. Specimens from Greene county are hardly distinguishable from those of Boone, Callaway or Montgomery counties. It varies from a soft, irregularly bedded, coarse-grained, green sandstone to an almost limpid, saccharoidal stratum. Where weathered, the sandstone is stained brown by the oxidation of small pyrite masses in the rock. It contains angular or rounded chert fragments in many places, which have been derived by erosion from the subjacent Ordovician limestone and it more or less commonly encloses pebbles of phosphatic material. On weathering, the Sylamore disintegrates into a soft rock on account of the leaching of the calcareous cement between the grains. Shepard has described a peculiar manner of weathering in which rounded, branching or tangled elevations are brought out in relief by greater resistance to weathering of certain portions of the rock. Features similar to these have been observed by the writer in Cooper county, and are mentioned in describing the Sylamore of northern Arkansas.

The Sylamore is most commonly exposed in steep valley sides where the absence of covering vegetation makes it conspicuous. Parts of the formation are massive but other portions are thin-bedded, and contain prominent ripple-marks and cross-bedding. The more massive facies of the Sylamore resembles the St. Peter sandstone and in some instances it has been so correlated.

Paleontologic character. As in central Missouri fossil invertebrates are practically absent in the Sylamore sandstone. The teeth of *Ptyctodus calceolus* are characteristic of the formation. In Greene county the *Ptyctodus* teeth are found at almost all exposures of the formation, but they are most numerous, according to Shepard^{42c} northeast of Springfield near the Phelps and Johnson mines and along Pomme de Terre river in southeastern Polk county. Fragmentary bones of large fishes, chiefly of the genus *Dinichthys* are reported^{1, 55} in the Sylamore of northern Arkansas.

Correlation. The Sylamore sandstone of southwestern Missouri may be correlated with the basal Kinderhook sandstone of

central Missouri on the one hand and it appears to be continuous with the Sylamore sandstone of northern Arkansas on the other. It has not been proved, however, that these somewhat variable, sandy deposits are strictly contemporaneous, although it is probable that they do not differ greatly in age. They are evidently related to a progressive, more or less rapid advance of the sea over the region, in which case the deposits farthest from the Ozark land should presumably be the first formed. There is indication at least locally that the sandstone is separated by an erosion interval from the superjacent formations.

Concerning the relation of the Sylamore sandstone to the formations with which it is associated in Greene county as described by Shepard^{42b} there is question. He referred to the Devonian four formations, respectively, in order upward, "Eureka" or black shale, "King" limestone, "Sac" limestone and "Phelps" sandstone.

The "Eureka" (Chattanooga) shale is a black, bluish or green shale which has been recognized at few places in Greene county. An exposure on James river near Frasers (sec. 29, T. 27 N., R. 22 W.), is indicated as most typical. The section is described as follows:^{42c}

(22) Section Near Fraser's, James River, Christian County (after Shepard)

		Thickness
		Feet. Inches.
(Osage group)		
"Chouteau" (Pierson) limestone		
Limestone, yellowish, impure, magnesian, fine-grained.		10
(Disconformity)		
(Kinderhook group)		
"Hannibal" limestone (Compton)		
Limestone, blue, to gray, rather hard compact, breaking with conchoidal fracture, somewhat variegated in color.		20
"Eureka" shale (Chattanooga)		
Shale, bluish black, carbonaceous, soft, somewhat fossiliferous, contains numerous small crystals of pyrite.		3-4
"Phelps" sandstone ? (Sylamore)		
Sandstone, bluish gray, rather fine-grained, irregularly bedded, pyritiferous.		4-6
("Sac" limestone ?)		
Limestone, dark, highly siliceous, carbonaceous, changing downward into a shaly, greenish mottled limestone.		3
"First Magnesian" limestone (Jefferson City ?)		
To level of James River		

The "King" limestone^{42d} is a light ashy gray, soft, fine-grained, compact, magnesian "cotton rock," characterized generally by a well defined horizontal lamination. It rarely exceeds a thickness of 1 or 2 feet and as it weathers rapidly exposures are not frequent. It is found beneath the "Sac" lime-

stone in the north part of Greene county but in the south is reported to underlie the "Phelps."

The "Sac" limestone^{42e} is a purplish gray or drab, magnesian rock with thick, massive layers. It is very compact, crystalline, and locally contains a large amount of pyrite. Its average thickness ranges from 4 to 10 feet. Its chief occurrence is along Sac river in northern Greene county.

The stratigraphic relation of the "Sac" limestone to the "King," is not in question, for the two have been observed at a number of points, the "Sac" in most cases protruding as a shelf over the easily eroded "King" limestone. The "Sac" has been recognized beneath the "Phelps" sandstone by Shepard who observed that the upper surface of the "Sac" is in general irregular, and that the "Phelps" is locally separated from the "Sac" by a clay layer.^{42e} The "Phelps" is, therefore, according to Shepard, at least slightly unconformable on the "Sac" limestone. Careful examination of the data available concerning these formations indicates no reason to believe that the Chattanooga shale underlies the "Sac" and "King" limestones. So far as can be learned, it is nowhere actually observed in this position, and it is possible that the limestone between the "First Magnesian" limestone and the "Eureka" (Chattanooga) shale at Fraser's may represent either the "Sac" or the "King." There is indication that the Chattanooga overlies the Sylamore sandstone, although in Greene county both formations are very patchy in distribution.

If the Sylamore sandstone and Chattanooga shale are transferred from the position assigned them by Shepard there is little to indicate that the remaining "Sac" and "King" limestone belong to the Devonian, assuming that the Chattanooga is Devonian. Both are entirely lacking in organic remains, so far as known. They are highly magnesian in character and resemble the underlying "Magnesian series" of the Ordovician so closely that in many cases they may "be confused with very similar beds of the First and Second Magnesian limestone."^{42d}

CHATTANOOGA SHALE

The Chattanooga shale of southwestern Missouri is a rather non-persistent, black, carbonaceous shale, including locally, green or bluish shale.

Distribution and thickness. The most continuous outcrops of Chattanooga shale in Missouri are found in McDonald county,

on Elk river in the vicinity of Noel. In the railroad cuts of the Kansas City and Southern Railway and in places along the new highway from Noel to Joplin, both of which follow the valley of Elk river, are excellent exposures of the Chattanooga, though commonly only the upper 6 or 8 feet of the formation are seen. Its maximum thickness in this vicinity is about 20 feet as observed one-half mile south of Noel. Farther east on Mill Creek (sec. 30, T. 21 N., R. 32 W.), Marbut^{78a} found 30 feet of black shale, and on Sugar creek, in the southeast corner of McDonald county, he reported a measurement of 50 feet for the formation. In Barry county the Chattanooga shale is much thinner. At an exposure on Roaring river (sec. 34, T. 22 N., R. 27 W.), it is 12 feet in thickness beneath thin-bedded, buff limestone, and overlying 80 feet of magnesian Ordovician limestone. According to Marbüt, who has made extensive examinations of the region, the Chattanooga shale is absent in southern Missouri east of Barry county. In Greene and Christian counties, however, it is represented by a few very thin patches along James river. The best exposures according to Shepard^{42f} is found in western Christian county, near Fraser's on James river, where the shale has a thickness of 3 to 4 feet. Well records in Greene county in a few instances indicates the presence of the Chattanooga with a thickness ranging up to 6 feet. In connection with studies upon the origin of the lead and zinc deposits of the Joplin region Siebenthal⁴⁶ has published a sketch map indicating extensive areas of Chattanooga shale on Sac river in northern Greene and southern Polk counties, on James river in eastern Greene and across Webster counties and on Finley Creek, Christian county north of Sparta. Numerous sections published by Shepard, field notes by Weller and the examination of the writer in parts of the region do not indicate this distribution of the Chattanooga shale.

The Chattanooga attains a thickness of 25 to 50 feet in McDonald and Barry counties, but in a northeast direction it becomes thin and discontinuous. A short distance south of the Missouri-Arkansas boundary its average thickness is 30 to 50 feet and ranging to more than 70 feet in the Fayetteville quadrangle. There is, however, a marked variation in thickness even within short distances.

Lithologic character. The Chattanooga is an argillaceous, fissile, black shale, with a minimum amount of sandy material. The carbonaceous content of the formation consists of minutely

divided organic material sufficient to give the black color which constitutes one of the most constant characters of the shale, and of minute, resinous spore cases, *Sporangites*, similar to those of the Chattanooga shale of Tennessee and Kentucky. The shale has a fetid, but hardly a bituminous odor. On distillation oil has been obtained, but never in sufficient quantities to be of commercial value. Drill holes have encountered small pockets of natural gas near Noël. Iron pyrite, which weathers out as nodules and concretions, is rather common in some parts of the formation. The Chattanooga has a jointed structure, with the joints obliquely inclined to the bedding, and shows a tendency to break into prismatic blocks. It breaks down readily under the attack of weathering agencies and the presence of the shale is commonly indicated only by gentle rounded grassy slopes. Good exposures are limited to places where erosion is active, or where man has uncovered it.

Paleontologic character. Fossils are rare in the Chattanooga shale. A few specimens of *Lingula*, somewhat similar in form to *Lingula subspatulata* M. & W. are reported,^{55, 66} but these are of little diagnostic value. Other organic remains of more or less common occurrence are the teeth of conodonts, fish scales and plates and occasional fragments of fish bones. Pieces of fossil wood *Dadoxylon* were found in the Chattanooga of northwestern Arkansas.¹ A small collection from the Chattanooga on Wilson creek near its junction with James river in western Christian county, which was made by Weller⁶⁶ includes the following species.

XI. Fauna of the Chattanooga Shale on James River, near Fraser's, Western Christian County

Brachiopods

Lingula sp. cf. *L. subspatulata* M. & W.
Orbiculoidea sp.
Chonetes sp. cf. *C. logani* N. & P.
Ambocoelia parva Weller

Crustacean

Spathiocaris emersoni Clarke

Fish

Scales

The crustacean *Spathiocaris emersoni* Clarke is known elsewhere from the Chattanooga shale of Hardin county in southern Illinois, and in the Sweetland Creek shale near Muscatine, Iowa. Shepard^{42c} has mentioned the occurrence of numerous casts of a species of *Liorhynchus*. More extensive collections from shale beds in northern Arkansas referred to the Chattanooga by Williams^{77b} include the following species.

XII. Fauna of the Chattanooga Black Shale on War Eagle Creek, Washington Co., Arkansas

Brachiopods

Chonetes sp. cf. *C. scitulus* Hall
 Chonetes sp. cf. *C. ornatus* Shumard
 Productella sp. cf. *hallana* (concentrica) Hall
 Rhipidomella *thiemi* (White)
 Rhipidomella *vanuxemi* Hall

Schizophoria sp. cf. *S. resupinata* (*S. swallovi* ?)
 Spiriferina sp. cf. *S. solidirostris* White
 Spirifer *marionensis* Shumard
 Cyrtina *acutirostris* (Shumard)
 Dielasma sp. cf. *D. burlingtonense* White
 Rhynchonella sp. cf. *R. pleurodon* Phillips

Associated with these species found in the black shale are a number of forms from a green and blue shale, identified by Williams as follows:

XIII. Fauna of Green and Blue (Chattanooga?) Shale, Northern Arkansas

Brachiopods

Leptaena *rhomboidalis* Wilckens
 Chonetes *illinoisensis* Worthen
 Productus sp.
 Rhipidomella *burlingtonensis* Hall
 Schizophoria *swallovi* Hall ?
 Rhynchonella *sagerina* Winchell ?

Rhynchonella *acuminata* var.
 Dielasma sp.
 Spiriferina ? *octoplicata*
 Spirifer *biplicatus* Hall ?
 Spirifer ? *compactus* Meek
 Spirifer *winchelli* Herrick
 Athyris *hannibalensis* Swallow

Correlation. The correlation of the black shale of southwestern Missouri and northern Arkansas with the Chattanooga black shale of Tennessee, is based on a similarity of lithologic character, the meagre organic remains which have been observed, and the apparent equivalence of their stratigraphic position. The similarity in lithologic character is not highly significant, for black shales resembling the Chattanooga are known at different geologic horizons. The minute *Sporangites* which have been observed are probably more important, though hardly sufficient evidence on which to base the correlation alone. The black shale of southwestern Missouri and northern Arkansas and the Chattanooga shale of central Tennessee, immediately overlie an unconformity of importance. They represent the initial deposits in an advance of the sea following a long erosion period. Both in Tennessee and on the southern flank of the Ozarks there are deposits of coarse sandstone and phosphatic material at the base of the shale. The formations occupy, therefore, the same relative stratigraphic position. The Chattanooga of Tennessee is exposed almost continuously along the west side of the Nashville dome in the central part of the state,

and may be traced to the edge of the Mississippi embayment, where it is covered by younger sediments. The shale reappears on the west side of the embayment and crops out more or less continuously to southwestern Missouri and northwestern Oklahoma. The essential equivalence of the black shale in southwestern Missouri to the Chattanooga shale of Tennessee is strongly suggested.

COMPTON LIMESTONE

Somewhat widespread in the southwestern Missouri region, as present data indicate, there is a bluish drab, compact limestone at the base of the Northview formation which contains a fauna typically representative of the Chouteau. This limestone cannot be correlated directly with previously recognized stratigraphic units, and the name Compton limestone is proposed.

Distribution and thickness. The Compton limestone is best exposed along James river in the vicinity of Compton, near the west line of Webster county. Outcrops are frequent south of Northview and farther east in Webster county north and northwest of Diggins. The exposed thickness of the formation in this region varies from 5 to 25 feet. A section measured by Weller at Bridwell's Hill (sec. 3 T. 29 N., R. 19 W.), on James river near Compton shows the relations of the formation in this district.

(23) Section on James River Near Compton, Webster County (Measured by Stuart Weller)

	Thickness Feet. Inches.
Chert and residual soil.....	20
Osage group	
Keokuk limestone ?	
6. Limestone, bluish gray, coarse-grained, crinoidal, containing numerous fossils.....	20
Burlington limestone	
5. Limestone and chert, limestone gray, hard, chert constituting more than one-half the formation, in bands 2 inches to 1 foot, 6 inches in thickness.....	20
4. Limestone, gray to white, hard, massively bedded, merges without break into the subjacent Pierson limestone.....	30
Pierson limestone	
3. Limestone, yellowish brown, magnesian, weathers to rock resembling grit.....	20
Kinderhook group	
Northview formation	
2. Sandstone, yellow, fine-grained and shale yellow and blue, soft, partially concealed.....	38
Compton limestone	
1. Limestone, gray, tough, compact, in layers about 6 inches thick (exposed).....	22

As shown by sections a short distance from Bridwell's Hill the formation directly underlying the Compton is the Jefferson City (?) dolomite, the Sylamore and Chattanooga being absent. At Cedar Gap, where an eastward projection of the Mississippian extends into Wright county, it is represented by about 12 feet of dense, drab limestone. The following section was measured by Rowley⁷³ a short distance east of Cedar Gap.

(24) Section East of Cedar Gap, Wright County (after Rowley)

		Thickness	
		Feet.	Inches.
Clay with Burlington chert			
Mississippian			
Kinderhook group			
(Northview shale)			
4. Shale, with a few feet of "vermicular" sandstone at top containing the characteristic "cocktail" fucoid.....		20	
(Compton limestone)			
3. Limestone, blue, weathering white, thinly bedded.....		12	
2. Shale, blue, clayey.....			8
Unconformity			
Ordovician			
1. Limestone, magnesian, massive (exposed).....		8	

To what extent the Compton limestone extends toward the southwest along the border of the Mississippian in Douglas, Christian and Stone counties, is not certain. Shumard⁴⁵ has described a limestone 25 to 50 feet in thickness beneath the Northview sandstone and shale in Wright, Ozark and Douglas counties, which may represent the Compton limestone. It is a rather coarse textured, subcrystalline rock, breaking with an uneven fracture. It unconformably overlies the Ordovician. The Compton is apparently represented on James river and Finley creek in Christian and Stone counties but is only a few feet thick. In Greene county this limestone is generally less than 15 feet thick. It has been recognized on Little Sac river north of Springfield and is well developed in the northern and northeastern parts of the county. In southern Polk county the Compton is found near Wishart, southwest of Bolivar, as shown in the following section.

(25) Section at Wishart, Polk County (Measured by Stuart Weller)

		Thickness	
		Feet.	Inches.
Mississippian			
Kinderhook group			
Northview formation			
3. Sandstone, yellow, fine-grained, containing numerous worm borings. Thin bedded, with intercalated shale. Iron pyrite.....			7
Compton limestone			
2. Limestone, drab, compact, tough, in layers 3 in. to 5 ft. thick. Is quarried along shaly seams for curbing and flagstones. Fossiliferous, containing <i>Spirifer</i> , <i>Productus</i> , pelecypods and fish teeth.....			12
Unconformity			
Ordovician			
1. Limestone, magnesian, forming floor of quarry.			

The Compton has not been traced farther northwest. It appears to be represented in certain well borings within the Mississippian area of southwestern Missouri.

Lithologic character. The Compton limestone is a light bluish drab, or grayish blue, compact limestone, very fine-grained and breaking with a conchoidal fracture. It is distinctly tougher and somewhat different in texture from the typical Chouteau limestone of central Missouri. The beds are generally of moderate thickness, averaging 6 to 8 inches, but in places they are of as much as 2 feet thick. The upper beds merge into the soft bluish shale of the Northview formation. As observed on Finley creek, the rock is very compact, hard, fine-grained, breaking with a splintery, conchoidal fracture.

Paleontologic character. The Compton limestone is not abundantly fossiliferous at any locality where it has been examined but it contains a sufficiently well marked fauna to permit comparison with other formations of the Kinderhook. A collection made by Weller at an old quarry on Little Sac river, eight miles north of Springfield, just east of the Springfield-Fair Grove road, shows the following species:

XIV. Fauna of the Compton Limestone on Little Sac River, Greene County

Corals

- Cyathaxonia tantilla (Miller)
- Zaphrentis sp. cf. C. chouteauensis
Miller
- Palaeacis sp.

Worm

- Spirorbis blairi Miller ?

Blastoids

- Schizoblastus roemeri (Shumard)
- Schizoblastus sampsoni (Hambach)

Crinoids

- Platycrinus absentivus Miller
- Platycrinus annosus Miller
- Platycrinus olliculus Miller
- Dichocrinus inornatus W. & S.

Bryozoans

- Lioclema sp.
- Rhombopora sp.

Brachiopods

- Leptaena analoga (Phillips)
- Chonetes logani N. & P.

- Productus calhounensis n. sp.
- Productus sampsoni Weller
- Avonia ? blairi (Miller)
- Rhipidomella tenuicostata Weller
- Schizophoria sp. cf. S. swallovi (Hall)
- Camarotoechia tuta (Miller)
- Shumardella missouriensis (Shumard)
- Shumardella obsolens (Hall)
- Cranaena occidentalis (Miller) ?
- Dielasma chouteauense Weller
- Cyrtina sp.
- Spirifer gregeri Weller
- Spirifer louisianensis Rowley
- Brachythyris chouteanensis (Weller)
- Syringothyris missouri Hall & Clarke
- Athyris sp.
- Cliothyridina sp.

Gastropods

- Platyceras paralum W. & W.
- Platyceras sp.
- Gastropod gen. and sp.

Crustacean

- Griffithides ? sedaliensis Vogdes ?

In the Compton limestone at the exposure of Cedar Gap, described by Rowley,⁷⁸ the following fauna is reported.

XIV-A. Fauna of the Compton Limestone at Cedar Gap, Wright County

Corals

Zaphrentis sp.

Amplexus sp.

Blastoid

Schizoblastus sampsoni (Hambach)

Crinoids

Actinocrinus sp.

Platycrinus allophylus Miller

Platycrinus sp.

Brachiopods

Chonetes sp.

Spirifer sp.

Gastropods

Loxonema sp.

Platyceras sp.

Correlation. A faunal study of the Compton limestone indicates close relationship with the Chouteau of central Missouri. However, its stratigraphic position beneath the Northview sandstone and shale indicates either that the characteristic elements of the Chouteau fauna appeared earlier in the southwest Missouri region than in central Missouri, or that the Northview is relatively younger than has been supposed.

There are two main elements in the fauna of the Compton limestone, one consisting of echinoderms, the other of brachiopods, the latter group being numerically the more important. The brachiopods include a number of more or less wide-ranging common Chouteau species: *Pustula concentrica*, *Leptaena ananoga*, *Chonetes logani*, *Camarotoechia tuta*, *Dielasma chouteauense*, *Cranaena occidentalis*, *Syringothyris missouri*, *Shumardella missouriensis* and *S. obsolens*. The remaining species are all suggestive of the higher divisions of the Chouteau limestone, some species, such as *Productus sampsoni* and *Cliothyridina prouti* being characteristic of the Fern Glen formation. *Productus calhounensis* has been recognized elsewhere only in the Chouteau limestone at Dogtown creek, Calhoun county and near Grafton, Jersey county, Illinois. It is an easily distinguished form and its presence in western Illinois and southwestern Missouri is an interesting link between the Kinderhook of these two regions. With slight exception the evidence of the brachiopods points to a relatively high position in the Kinderhook for the Compton fauna.

The echinoderms are more numerous both in species and individual specimens than is common in collections from the Chouteau limestone. Especially abundant are the blastoids,

Schizoblastus romeri and *S. sampsoni* which in central Missouri appear fairly closely restricted to the upper part of the Chouteau limestone. *S. romeri* has been identified from the Sedalia or Fern Glen at Chesapeake, Lawrence county, northwest of Marionville. The species of *Platycrinus* with which the Compton specimens are identified are suggestive of the Sedalia rather than the Chouteau limestone as restricted. *Dichocrinus inornatus* is described from the "upper Kinderhook" at LeGrand, Iowa, which is regarded by the writer as initial Osage. The evidence of the brachiopods is sustained by the echinoderm element of the fauna.

It seems best to regard the Compton limestone as a thin extension of a part of the Chouteau limestone of central Missouri. The character of its fauna suggests a position higher in the Kinderhook than would be supposed from its stratigraphic position beneath the Northview formation. It is almost certainly as young as the typical Chouteau limestone, and is not at all equivalent to the Louisiana limestone.

NORTHVIEW FORMATION

The Northview formation consists of sandstone and shale and comprises the chief clastic unit of the Kinderhook in southwest Missouri. There is no difficulty in its recognition in the field, especially as abundant, tubular worm borings in the sandstone are absent in associated formations.

Distribution and thickness. Partial exposure of the Northview, particularly the sandstone member, are not infrequent throughout the area in which the formation occurs. On account of the readiness with which it yields to weathering, however, it is rarely completely exposed, nor are outcrops as numerous as those of the associated limestones.

The "vermicular" sandstone of the Northview has been reported at least as far north as Cedar county. According to Broadhead^{7a} the formation has a thickness of 44 feet on Sac river east of Stockton. It is probably present in St. Clair county north of Cedar. In Polk county the Northview is well developed although examination has not been made with regard to its areal distribution. Swallow^{51d} mentions 75 feet of "Vermicular sandstone and shale" about 15 miles south of Bolivar on the Springfield-Bolivar road and fossils collected from the shale in the vicinity of Bolivar are included in the collections of Walker Museum, University of Chicago. Shepard's⁴² investigations

have shown that the Northview formation is widespread in Greene county, varying in thickness from 10 to 100 feet. The best exposures are found along Pierson creek east of Springfield, on Little Sac river and on the south side of Pomme de Terre river in the north and northeastern parts of the county. The formation is apparently absent in the southern part of Greene county and in Christian county.

In the vicinity of its type locality at Northview, Webster county, and along James river eastward for a considerable distance the Northview formation is well exposed at intervals, its average thickness, being approximately 40 to 50 feet. It extends into Wright county where Rowley⁷⁸ has described a partial exposure of the formation east of Cedar Gap from which a number of the characteristic fossils of the shale were collected. According to Shumard⁴⁵ the Northview extends some distance northeast of Cedar Gap and is present in outliers as far as the line between Wright and Texas counties. Along the Mississippian border southwest of Wright county the Northview has not been reported. At Reeds Spring in Stone county, the St. Joe rests directly on the Ordovician.

Lithologic character. The Northview formation typically contains two members, a fine-grained, yellow sandstone above, and a blue or bluish green shale below. No sharp line of division separates these members and one may increase at the expense of the other with much variation. The sandstone in few instances exceeds a thickness of 25 feet; the shale, which is in general the more persistent, has an usual thickness ranging from 25 to 75 feet.

The color of the sandstone varies somewhat from a light yellow or buff to brown, and in some cases it is distinctly blue. Many of the fossil specimens from the Northview sandstone are preserved in a reddish brown rock, the red color having been caused by the action of fire.⁶² The sandstone is characteristically very fine-grained and in general more or less friable. In many cases, however, it is hard and resistant to weathering, and its outcrop forms a well defined bench or terrace. The worm burrows in the sandstone are filled with less indurated material, slightly different in color from the remainder of the rock. This filling is removed rapidly on weathering and the borings become conspicuous.

The shale member is blue or bluish green. It is soft and weathers rapidly from beneath the sandstone, which being in-

sufficient in strength to form projecting ledges, breaks down and obscures the outcrop of the shale.

Paleontologic character. In general, fossils are rare in the Northview formation. They are perhaps most common in the sandstone but they have been reported adequately from only one locality, the vicinity of Northview, Webster county.⁶² The manner in which the sandstone fossils are preserved is of interest. Although the calcareous shells have been removed by solution, no cavity exists and the fossils are not, therefore, fossil casts. Weller believes that the shell substance was removed soon after the shell was buried, and that the cavity was closed by pressure before the consolidation of the sediment. In some cases the worm borings appear to penetrate the fossil shells. The sandstone at Northview contains the following species:

XV. The Fauna of the Sandstone Member of the Northview Formation at Northview, Webster County

Coral

Zaphrentis sp.

Worm

Scalarituba missouriensis Weller

Bryozoan

Fenestella sp.

Brachiopods

Schellwienella inaequalis (Hall) ?

Chonetes multicostus Winchell ?

Chonetes glenparkensis Weller

Chonetes sp.

Productus sp.

Pustula concentrica (Hall)

Rhipidomella burlingtonensis Hall

Schizophoria swallovi (Hall) ?

Cranaena hannibalensis Moore

Spiriferina sp.

Spirifer gregeri Weller ?

Spirifer osagensis Swallow

Spirifer sp. 1, 2.

Syringothyris carteri (Hall)

Ambocoelia parva Weller

Athyris lamellosa (L'Eveille)

Cliothyridina sp.

Pelecypods

Sanguinolites websterensis (Weller)

Sphenotus sp.

Promacrus cuneatus Hall

Promacrus websterensis Weller

Elymella missouriensis M. & G.

Cardiopsis erecta Weller

Edmondia missouriensis Weller

Edmondia sp.

Palaeoneilo truncata Hall

Palaeoneilo sp.

Schizodus aequalis Hall

Pernopecten cooperensis (Shumard)

Crenipecten laevis Weller

Crenipecten winchelli Meek ?

Modiolus northviewensis (Weller)

Pelecypods gen. and sp.

Gastropods

Tropidodiscus cyrtolites (Hall)

Bellerophon sp.

Euphemus ? sp.

Bucania ? sp.

Pleurotomaria sp.

Mourlonia northviewensis Weller

Porcellia rectinoda Winchell ?

Platyschisma missouriensis Weller

Straparollus sp.

Phanerotinus paradoxus Winchell

Loxonema sp.

Platyceras sp.

Cephalopods

Orthoceras indianense Hall

Triboloceras digonum (M. & W.)

Crustacean

Proetus sp.

Plant ?

Spirophyton sp.

A number of pelecypods and some gastropods in addition to these mentioned in the foregoing list are included in the collection from Northview, but they are not sufficiently well preserved to permit accurate identification.

The Northview sandstone of Cedar county, according to Broadhead⁷ contains many fossils. Only a very few, however, and these not specifically identified, are mentioned by him: *Orthotetes* sp., *Parallelodon* sp., *Pernopecten cooperensis* (Shumard), *Allorisma* sp., *Bellerophon* sp., *Phillipsia* sp.

The shale division of the Northview is comparatively barren in fossils. In a few localities, however, as near Bolivar, Polk county, and Cedar Gap, Wright county, they are numerous and weather out in a pyritized condition from the shale. These pyritized specimens are in most cases difficult to identify owing to the poor preservation of the shell and because only casts are found. They are more or less distorted by pressure before pyritization in most cases. Collections in Walker Museum, University of Chicago, contain a few specimens from the Northview shale in the vicinity of Bolivar, including *Athyris lamellosa* (L'Eveille) *Reticularia cooperensis* (Swallow) and *Rhipidomella burlingtonensis* Hall. From the Northview sandstone near Wishart, Polk county, a very typical specimen of *Grammysia hannibalensis* (Shumard) is also known.^{65a}

The most complete available information concerning the constitution of the Northview shale fauna is obtained from a collection of fossils east of Cedar Gap, Wright county, from which the following species have been identified.

**XVI. Fauna of the Shale Member of the Northview Formation at
Cedar Gap, Wright County**

<i>Coralis</i>	<i>Spiriferina subtexta</i> White
<i>Zaphrentis</i> sp. 1, 2, 3	<i>Spirifer gregeri</i> Weller
<i>Amplexus</i> sp. 1, 2	<i>Spirifer louisianensis</i> Rowley
<i>Blastoid</i>	<i>Ptychospira sexplicata</i> (W. & W.) ?
<i>Orophocrinus</i> ? sp.	<i>Athyris</i> sp.
<i>Crinoid</i>	<i>Cliothyridina tenuilineata</i> (Rowley) ?
Stems	<i>Cliothyridina</i> sp.
<i>Brachiopods</i>	<i>Pelecypods</i>
<i>Productus</i> sp.	<i>Cardiopsis</i> ? sp.
<i>Rhipidomella thiemei</i> (White)	<i>Edmondia</i> sp. cf. <i>E. missouriensis</i> Weller
<i>Dielasma chouteauense</i> Weller	<i>Parallelodon</i> sp.
<i>Girtyella cedarensis</i> Weller	<i>Modiolus northviewensis</i> (Weller)

Gastropods

Bellerophon blairi M. & G.
 Bellerophon n. sp.
 Bellerophon sp.
 Euphemus sedaliensis (M. & G.) ?
 Pleurotomaria sedaliensis Miller
 Pleurotomaria sp. cf. P. sp. (Chouteau)
 Murchisonia sp. 1, 2
 Platyschisma depressa Weller
 Platyschisma sp. cf. P. sp. (Chouteau)
 Straparollus ammon (W. & W.)
 Straparollus lens (Hall)
 Straparollus missouriensis (M. & G.)

Straparollus sp.
 Naticopsis n. sp.
 Loxonema tenuilineatum (Shumard)
 Loxonema sp. cf. L. sp. (Chouteau)

Cephalopods

Orthoceras sp. 1, 2
 Dawsonoceras sp. cf. D. whitei (Winchell)
 Phragmoceras sp.
 Prolecanites gurleyi Smith
 Muensteroceras ? osagense (Swallow)
 Muensteroceras ? sp.

Farther northeast in Wright County, Shumard⁴⁵ indicates there are numerous pyritized fossils in the "Vermicular" Northview shale. He mentions the following species:

XVII. "Vermicular" (Northview) Shale Fauna, Wright County (Shumard)

Orthis (Rhipidomella) abundant	Spirifer marionensis (osagensis ?)
Rhynchonella (Shumardella) missouriensis	Gastropods very numerous
Cyrtia (Cyrtina) acutirostris	Goniatites 2 sp.

The importance of the molluscan and cephalopod elements, especially the variety and abundance of the gastropods, is a noteworthy feature of the Northview shale fauna. This predominance is largely due to the clastic character of the formation.

Correlation. In a paper describing the fauna of the Northview sandstone, Weller⁶² has critically reviewed the elements in its composition and discussed their significance as to the age of the formation. The fauna is typically a Kinderhook assemblage and comparison with the faunas of other formations indicates that the closest relationship of the Northview is with the Chouteau limestone of central Missouri. Not only are most of the Northview species identified with Chouteau forms but a number of undescribed species, chiefly gastropods, appear on comparison with Chouteau limestone fossils from Pettis county to be identical. These undescribed species are in general represented by material not sufficiently well preserved to have permitted the recognition of their essential character with certainty, but there is little question of the correspondence of the forms compared. The close similarity between the Northview and Chouteau faunas indicates that the one is equivalent at least in part to the other, the Northview representing perhaps a clastic phase of the Chou-

teau. The occurrence of *Spirifer gregeri* and *Orophocrinus*? closely resembling typical forms from the lower Osage beds suggests a high position in the Kinderhook. The contact between the Northview and the Pierson limestone appears to indicate conformity. Since the Compton limestone underlying the Northview also contains a large number of late Kinderhook or even early Osage elements it seems necessary to refer the Northview to the uppermost part of the Kinderhook.

The Northview fauna has much in common with that of the upper yellow sandstone (Bed 5) in the Kinderhook at Burlington, Iowa. This correspondence, which has been emphasized by Weller is due to the fact that both are clastic facies of the common widespread Chouteau fauna. In both, the molluscan element is an important feature. The sandstone at Burlington is apparently conformable with the beds below and above.

With the Hannibal formation of northeastern Missouri which has in general been considered as the direct equivalent of the Northview, the indications of faunal relationship are less well defined. This is due in part to lack of knowledge concerning the complete fauna of the Hannibal, but a comparison of the known Hannibal species with those of the Northview shows a smaller number of identical forms than is observed on the comparison of the Northview and the Chouteau or Bed 5 at Burlington. In spite of this lack of close similarity in faunas it is not impossible that the Hannibal is at least partly equivalent in age to the Northview. The lithologic resemblance of one to the other is striking and their stratigraphic position is similar. Until more is learned with regard to the faunal relations of the two formations and their connection with associated deposits, definite correlation is not desirable, as they seem to have been deposited in different basins and no direct connection is known.

CHOUTEAU LIMESTONE

Examination has not been sufficiently detailed in the southwestern Missouri region to permit complete description of the Chouteau limestone. There is really no sharp line of division between the regional subprovinces which have been distinguished in the description of the Kinderhook. Future study, it is believed, will show the presence of limestone beds referable to the Chouteau stratigraphically higher than the Northview formation, but so far as now indicated these beds are restricted to the

northern counties of the southwest Missouri region and constitute extensions of the Chouteau of central Missouri.

Distribution and thickness. Strata referable to the Chouteau are present in Benton, St. Clair, Hickory and probably Cedar counties. In the section at Warsaw, Benton county, studied by the writer, the Chouteau is fossiliferous and at least 25 feet in thickness. It is well exposed in the bluffs of Osage river two miles north of town and three miles northwest. As measured at Kiesinger bluff, north of Warsaw, the section is as follows:

26. Section at Kiesinger Bluff, Osage River, North of Warsaw, Benton County
SW. $\frac{1}{4}$ NE., $\frac{1}{4}$ Sec. 7, T. 40 N., R. 22W.

		Thickness	
		Feet.	Inches.
Osage group			
Burlington limestone			
	Limestone, light buff to gray, coarse crystalline crinoidal, very massively bedded. Chert in nodules and bands at various elevations.	55	
Sedalia limestone.			
6.	Limestone, light bluish gray, weathering yellow, fine-grained, subcrystalline, on weathered surface a very few crinoid fragments appear; coarse stylolites; thick bedded.	6	6
5.	Limestone, light brownish drab, magnesian, very massive, soft and uniform in texture, easily eroded, weathering in smooth rounded outlines. Contains <i>Chonophyllum sedaliense</i> .	3	
<i>Disconformity ?</i>			
Kinderhook group			
Chouteau limestone			
4.	Limestone, light bluish gray to drab, fine-grained, compact, impure, in thin, nodular layers with shaly partings. Very fossiliferous.	7	6
3.	Limestone, yellowish gray, fine-grained, soft, uniform in texture, massive.	2	
2.	Limestone, bluish or brown, earthy, beds thin and irregularly nodular, chert in bands 2 to 4 inches thick. Weathers with characteristic shelly appearance (exposed).	15	
1.	Covered to level of Osage River.	75	

The same divisions were observed on the See place, three miles northwest of Warsaw in a high bluff of Osage river. Examination in this region did not show the complete thickness of the Chouteau and the character of the immediately subjacent formations was not observed, but the formation is not more than 40 feet for the Ordovician was found in a small ravine near the section given above, almost to the elevation of the exposed base of the Chouteau.

Lithologic character. The Chouteau limestone as observed at Warsaw differs from that typically exposed in Cooper and Pettis counties, only a short distance north, in a number of minor respects. It is more brown in color, more impure in composition and tougher than the central Missouri Chouteau, but

retains the peculiar nodular, thin-bedded character which is so typical of a large part of the formation. The dark bluish black chert is flint-like as in the Chouteau farther north. It occurs in rather continuous bands in the thin-bedded limestone. The Chouteau in Benton county weathers in thin, shelly fragments irregular in size and shape, exactly in the manner commonly observed in weathered exposures elsewhere.

Paleontologic character. The Chouteau has afforded large collections of fossils near Warsaw, some of the species being represented by an unusually large number of individuals. The fauna as observed at Kiesinger bluff is indicated in the following list. The most fossiliferous portion of the exposed beds is the upper division of the formation (Bed 3); the remaining fossils were found in the lower division (Bed 1).

XVIII. Fauna of the Chouteau Limestone at Kiesinger Bluff, North of Warsaw, Benton County

	Bed 1	Bed 3
<i>Corals</i>		
<i>Zaphrentis tenella</i> (Miller) ?	—	x
<i>Zaphrentis</i> sp. 1, 2	—	x
<i>Homalophyllum calceolum</i> (W. & W.)	—	x
<i>Syringopora harveyi</i> Winchell ?	x	—
<i>Blastoid</i>		
<i>Schizoblastus roemeri</i> (Shumard) ?	—	x
<i>Bryozans</i>		
<i>Fenestella</i> sp.	—	x
<i>Fenestella</i> sp.	x	—
<i>Rhombopora</i> sp.	x	x
<i>Rhombopora</i> sp.	—	x
<i>Cystodictya</i> sp.	—	x
<i>Brachiopods</i>		
<i>Leptaena analoga</i> (Phillips)	x	x
<i>Leptaena</i> ? sp.	—	x
<i>Schellwienella</i> sp.	—	x
<i>Chonetes glenparkensis</i> Weller	x	x
<i>Chonetes illinoisensis</i> Worthen ?	—	x
<i>Chonetes</i> sp. cf. <i>C. shumardianus</i> de Kon.	—	x
<i>Chonetes</i> sp.	—	x
<i>Productus arcuatus</i> Hall	—	x
<i>Productus sampsoni</i> Weller	x	—
<i>Productus sedaliensis</i> Weller	—	x
<i>Productus ovatus</i> Hall ?	—	x
<i>Productus</i> sp.	—	x
<i>Pustula concentrica</i> (Hall)	—	x
<i>Pustula newarkensis</i> Moore	—	x

FAUNAL TABLE XVIII—Continued.

	Bed 1	Bed 3
<i>Brachiopods—Cont'd</i>		
<i>Rhipidomella burlingtonensis</i> Hall.....	—	x
<i>Schizophoria sedaliensis</i> Weller.....	—	x
<i>Schizophoria chouteauensis</i> Weller.....	x	—
<i>Camarotoechia tuta</i> (Miller).....	—	x
<i>Shumardella obsolens</i> (Hall).....	—	x
<i>Shumardella</i> sp.....	x	—
<i>Rhynchotreta ovata</i> (Greger).....	x	x
<i>Dielasma chouteauense</i> Weller.....	—	x
<i>Dielasma</i> sp.....	—	x
<i>Spiriferina subtexta</i> White.....	—	x
<i>Spirifer gregeri</i> Weller ?.....	—	x
<i>Spirifer louisianensis</i> Rowley.....	—	x
<i>Spirifer missouriensis</i> Swallow.....	—	x
<i>Spirifer osagensis</i> Swallow.....	—	x
<i>Spirifer platynotus</i> Weller ?.....	—	x
<i>Spirifer</i> sp.....	x	x
<i>Spirifer vantuyli</i> Moore.....	—	x
<i>Brachythyris chouteauensis</i> (Weller).....	x	x
<i>Brachythyris peculiaris</i> (Shumard).....	—	x
<i>Pseudosyrinx missouriensis</i> Weller.....	—	x
<i>Reticularia cooperensis</i> (Swallow).....	x	x
<i>Athyris iamellosa</i> (L'Eveille).....	—	x
<i>Cliothyridina</i> sp. cf. <i>C. tenuilineata</i> (Rowley).....	—	x
<i>Cliothyridina</i> sp.....	—	x
<i>Pelecypods</i>		
<i>Grammysia blairi</i> Miller.....	—	x
<i>Grammysia</i> sp.....	—	x
<i>Parallelodon</i> sp.....	—	x
<i>Myalina</i> n. sp.....	x	—
<i>Pernopecten cooperensis</i> (Shumard).....	—	x
<i>Cypricardina sulcifera</i> Winchell.....	—	x
<i>Gastropod</i>		
<i>Platyceras nasutum</i> Miller.....	—	x
<i>Crustacean</i>		
<i>Phillipsia</i> ? sp.....	—	x

Correlation. The Chouteau as described in the northern portion of the southwest Missouri region is without doubt a continuation of the same formation in Pettis county and the rest of central Missouri. It is to be noted, however, that a number of species included in the fauna of the beds at Warsaw are suggestive of the higher horizons of the formation or the succeeding Sedalia limestone. They include *Homalophyllum calceolum*, which is common in the Sedalia both in central and northeast Missouri,

Productus sampsoni, most commonly found in the Fern Glen but occurring also in the Sedalia and uppermost division of the Chouteau, *Schizophoria sedaliensis*, most common in the Sedalia limestone of Pettis county, and *Athyris lamellosa*, a common Fern Glen species. In this content of species suggestive of the succeeding Osage limestones, the Chouteau of Benton county is similar to the Northview sandstone and Compton limestone in Greene and Webster counties.

The Chouteau immediately underlies the magnesian Sedalia limestone which exhibits many of the peculiar lithologic features which distinguish the formation in Pettis county and contains the coral fauna widespread at this horizon. The formation beneath the Chouteau in Benton county has not been observed and the relation of the Chouteau to the Northview and Compton formations are indicated only on faunal and comparative stratigraphic bases.

SUMMARY

Sylamore sandstone. The oldest known Kinderhook deposit in southwestern Missouri is a white to greenish or brown sugary sandstone about 3 or 4 feet in average thickness containing in many places the teeth of *Ptyctodus calceolus*. Like the corresponding basal Mississippian sand in central Missouri the sandstone is irregular in distribution and thickness. This formation rests on an eroded surface of Ordovician and locally in northeastern Oklahoma of Silurian rocks.

Chattanooga shale. Black fissile shale referred to the Chattanooga is found in parts of southwestern Missouri, becoming thicker and more persistent southward into Arkansas. The formation attains a maximum thickness in Missouri of about 50 feet. Toward the north of this district the shale is patchy or absent. Scanty faunal evidence shows relationship with the Chattanooga shale of Tennessee and Sweetland Creek shale of Iowa. There is also a Chouteau element in the collections reported.

Compton limestone. The Compton limestone is a rather widespread but discontinuous formation in the lower part of the Kinderhook of southwest Missouri. It underlies the Northview formation and in most places rests unconformably on magnesian beds of the Ordovician. It is a bluish drab, fine-grained, compact limestone, with sharply conchoidal fracture, in beds varying in thickness from thin layers to more than 2 feet. It contains a Chouteau fauna.

Northview formation. The Northview formation comprises the chief clastic deposit of Kinderhook age in southwestern Missouri. There are two members—a lower soft, bluish green shale and an upper rather hard, fine-grained, yellowish brown sandstone characterized by abundant worm borings. The thickness of the Northview ranges from less than 10 feet to nearly 100 feet. The fauna is largely found in the sandstone but pyritized fossils are locally abundant in the shale. Comparison with the Chouteau fauna and with that of the upper yellow sandstone (Bed 5) of the Kinderhook at Burlington, Iowa, indicates close relationship. The Northview may be correlated with some portion, probably the uppermost part, of the Chouteau limestone. Notwithstanding the lithologic similarity of the Northview formation and the Hannibal sandstone and shale of northeastern Missouri, the faunas are not closely allied. It is possible that the Northview and Hannibal are partly equivalent but on the evidence now at hand the latter formation appears to be somewhat older.

Chouteau limestone. The Chouteau limestone is recognized in Benton county near Warsaw and has been reported southward in St. Clair and Cedar counties. The thickness of the Chouteau near Warsaw is at least 25 feet. Lithologically the Chouteau is somewhat unlike that of the type region in central Missouri, being more argillaceous, and slightly different in color, but the peculiar manner of bedding characteristic of the Chouteau is developed here and the texture of the rock is similar. The limestone is fossiliferous and contains a typical Chouteau fauna, but includes a number of species suggestive of horizons higher than the Chouteau. Its stratigraphic position, lithologic character, and fauna indicate that the limestone is an extension of the central Missouri Chouteau limestone.

THE SOUTHEASTERN MISSOURI KINDERHOOK *

INTRODUCTION

The record of the Kinderhook in southeastern Missouri is lacking in completeness as compared with other portions of the state, but it is one of interest, for it is possible to learn much from the gaps in the record as well as from the portion which is present.

General relations. Kinderhook beds are found in southeastern Missouri only in the northeast part of Jefferson county and in northern Ste. Genevieve county. A much larger area was doubtless at one time covered by the strata of the Kinderhook, but erosion has now shifted the place of exposure outward from the Ozark dome almost beyond the boundaries of the state. The Kinderhook rests unconformably on beds of Ordovician age, and is unconformably overlain by Osage strata.

Divisions. With the exception of a single exposure of black shale, the Kinderhook of southeastern Missouri is all referred to a single formation, named by Ulrich^{8a} the Sulphur Springs formation from a town in Jefferson county. It consists of three members, (c) an upper sandstone about 10 feet thick, named the Bushberg sandstone, (b) below this an oolitic limestone member, 1 to 5 feet thick, called the Glen Park limestone, and (a) a shale, entirely absent in most exposures but ranging to a maximum, according to Ulrich, of 15 feet. The black shale, tentatively referred to the Chattanooga by Weller overlies the Bushberg sandstone.

Pre-Sulphur Springs unconformity. Immediately beneath the Sulphur Springs formation wherever it is found in Jefferson and Ste. Genevieve counties, are strata of Ordovician age. In its most northern exposure in Ste. Genevieve county, the underlying formation is the Fernvale (Richmond) limestone. South of River aux Vases it is the shale member of the Thebes formation (Maquoketa). Throughout this region covered by the Kinderhook, the Silurian and the Devonian, which in a down faulted block on Little Saline creek attain a thickness of nearly 1,000 feet, are wanting. Weller has observed a section

*Description of the southeastern Missouri Kinderhook is based mainly on the work of Dr. Stuart Weller, who has given the writer access to field notes and unpublished manuscript.

on the Little Saline, about $1\frac{1}{4}$ miles southwest of Ozora, which shows the Bushberg sandstone resting on Thebes shale, while not more than a half mile distant the entire section of the Silurian and Devonian rocks is present. Before the deposition of the Sulphur Springs formation, the country had been reduced to a peneplain cutting across the Ordovician, Silurian and Devonian beds. The magnitude of the erosion interval immediately preceding the deposition of the Sulphur Springs formation is apparent.

Distribution and thickness. The Sulphur Springs formation is well exposed in a number of places in northeast Jefferson county in the vicinity of Sulphur Springs and Kimmswick. In Ste. Genevieve county the formation is present only north of the faulted zone on Little Saline creek. It is well exposed in only two or three places in the intervening distance, being either wanting or covered. In the northern part of the county, in Snell Hollow, about 1 mile south of Brickeys, it is exposed for a distance of nearly one-half mile. The Glen Park limestone member is typically developed at this locality and may be recognized easily. Between River aux Vases and Little Saline creek to the southwest, the formation is represented by the Bushberg sandstone which outcrops in the heads of a number of ravines in the eastward extension of the Beckett Hills.

The Sulphur Springs formation is absent at certain localities in the region, as in the bluffs at Salt Lick Point, Monroe county, Illinois, on Mississippi river opposite Valmeyer. Here the red Fern Glen limestone rests directly on the yellow Thebes shale of Upper Ordovician age.⁶⁹

Near Sulphur Springs the formation has a total thickness ranging from approximately 10 feet to nearly 30 feet. The maximum thickness of the Bushberg sandstone in the region between Little Saline creek and River aux Vases is probably not more than 10 feet. In places it does not exceed 5 feet. The black shale which is observed at one locality has a thickness of approximately 10 feet.

Lithologic character. The Sulphur Springs formation is variable in lithologic character, as might be expected in a thin, locally developed sea deposit that was made after a long period of subaerial erosion. The three divisions recognized by Ulrich at the type locality do not extend throughout the southeast Missouri region, though the oolitic limestone and sandstone members are both recognizable in Ste. Genevieve county.

The lower shale member is mainly yellowish brown, and argillaceous. It is not characterized by distinctive faunal or lithologic characters and has not been definitely recognized except at Sulphur Springs. The Glen Park limestone member is a light gray, more or less impure oolite and locally is highly fossiliferous. The Bushberg sandstone member is a coarse, yellowish brown rock, rather soft and porous, in texture not unlike the much older St. Peter sandstone. In some outcrops the basal portion of the sandstone is a conglomerate, including pebbles of black phosphatic material similar to those described from the Sylamore sandstone of northern Arkansas or the Hardin sandstone of Tennessee. Associated with the pebbles are numerous fragments of fish teeth, among which may be distinguished worn specimens of *Ptyctodus*. At one locality on Frenchman creek, the Bushberg is represented by a bed of phosphatic nodules beneath which is a black phosphatic rock containing numerous specimens of *Lingula*. Locally, as south of Kimmswick, the Sulphur Springs is represented by a rather coarse, greenish sandstone, with black pebbles and worn fragments of *Ptyctodus* teeth similar in almost all respects to the Sylamore sandstone of central and southwestern Missouri.

The greater portion of the rock at the only known exposure is a fissile carbonaceous shale, similar in lithologic character to the Chattanooga shale of northern Arkansas and Tennessee. Thin, rather discontinuous seams of grayish brown sandstone, a fraction of an inch in thickness are included. The sand in these lenses is similar to that constituting the underlying Bushberg sandstone, and although the actual contact between the shale and sandstone is covered, Weller believes that a gradual transition probably exists which indicates the absence of any unconformity. The sandstone contains concretions of marcasite.

Stratigraphy. The relation of the Sulphur Springs formation to the formations above and beneath it in the region of its type locality is shown by the following section measured by Weller:

(27) Section at Goetz's Quarry, Glen Park, Jefferson County

		Thickness	
		Feet.	Inches.
Mississippian			
Osage group			
Burlington limestone			
	11. Limestone, light gray, coarse crystalline, crinoidal, abundant chert. Typical Burlington limestone.....	18	
Fern Glen formation			
	10. Limestone, greenish gray, more or less crystalline, with chert bands.....	7	
	9. Limestone, red, with green blotches, argillaceous, with chert in lenses and bands. Fossiliferous.....	8	6
	8. Covered.....	6	
	7. Limestone, yellow or gray, hard, somewhat crystalline, fossils not abundant.....	4	
<i>Disconformity</i>			
Kinderhook group			
Sulphur Springs formation			
Bushberg member			
	6. Sandstone, yellow, becoming brown on weathering, fine-grained. No fossils observed.....	14	
	5. Shale, sandy.....		4
Glen Park limestone member			
	4. Limestone, light colored, oolitic, fossiliferous. In quarry face appears as lenticular masses in depressions of the subjacent shale; in the railroad cut nearby it is a continuous limestone band.....	1	3
<i>Unconformity</i>			
Ordovician			
Thebes shale			
	3. Shale, yellowish or brownish, fissile, weathering gray. The upper part reworked by the sea which deposited the Sulphur Springs, disturbing the stratification and introducing phosphatic nodules and an occasional fossil of the younger beds. Fauna of the Upper Ordovician Maquoketa shale.....	4	
Fernvale limestone			
	2. Limestone, dark brown or blue, hard, fairly massive. Very fossiliferous, containing large numbers of <i>Rhynchotrema capax</i>	1	6
Kimmswick limestone			
	1. Limestone, light colored, highly crystalline, massive. Very fossiliferous. (Trenton).....	55	

A well exposed section in a cut of the St. Louis, Iron Mountain and Southern railroad about 2 miles north of that just described shows 1 foot or less of greenish sandstone with black pebbles and *Ptyctodus* teeth, unconformably between Thebes and Sedalia (?).

Paleontologic character. The fauna of the Sulphur Springs formation is almost entirely derived from the Glen Park limestone member. As described by Weller⁶⁸ this limestone includes the following species:

XIX. Fauna of the Glen Park Limestone at Glen Park, Jefferson County

Localities*	1	2
<i>Corals</i>		
Zaphrentis sp.	x	—
<i>Crinoids</i>		
Agaricocrinus sp.	x	—
Actinocrinus sp.	x	—
<i>Brachiopods</i>		
Schuchertella sp.	x	?
Chonetes glenparkensis Weller.	x	—
Rhipidomella sp.	—	x
Camarophoria hamburgensis Weller.	—	x
Rhynchonella sp.	—	x
Rhynchotretra sp.	—	x
Camarotoechia sp.	x	—
Dielasmella compressa (Weller).	x	—
Hamburgia typa Weller.	x	—
Atrypa infrequens Weller.	x	—
Delthyris missouriensis Weller.	x	x
Delthyris suborbicularis Weller.	x	—
Spirifer jeffersonensis Weller.	x	—
Syringothyris bushbergensis Weller.	—	x
Composita sp.	x	—
<i>Pelecypods</i>		
Nucula glenparkensis Weller.	x	—
Leda diversoides (Weller).	x	—
Parallelodon sulcatus (Weller).	x	—
Schizodus appressus (Conrad).	x	—
Modiomorpha lamellosa Weller.	x	x
Modiolus missouriensis Weller.	x	—
Cypricardinia subcuneata Weller.	x	x
Snellia semielliptica Weller.	—	x
Streblopteria sp.	—	x
<i>Gastropods</i>		
Bellerophon jeffersonensis Weller.	x	—
Bellerophon ulrichi Weller.	x	—
Ptychomphalus missouriensis Weller.	x	—
Tropidodiscus cyrtolites (Hall).	x	—
Naticopsis paucivolutus Weller.	x	—
Platyceras erectoides Weller.	x	—
Platyceras evolutus Weller.	x	—
Platyceras glenparkensis Weller.	x	—
Platyceras sp.	—	x
Orthonychia jeffersonensis Weller.	x	—
Orthonychia ungula Weller.	x	—
Orthonychia sp.	—	x
<i>Fish</i>		
Ptyctodus eastmani Weller.	x	x

*Localities: 1. At Glen Park, Jefferson County. 2. Snell Hollow, 1 ¼ miles south of Brickeys, Ste. Genevieve County.

Weller^{68b} has pointed out a relationship of the Glen Park limestone fauna with the Hamilton faunas of the eastern Devonian. The Devonian aspect of the Glen Park fauna is most marked among the molluscs, but some of the brachiopods, such as *Atrypa*, are suggestive of beds older than the Mississippian.

The Bushberg sandstone, on account of its rather porous, open texture, does not commonly contain organic remains other than the more or less worn *Plyctodus* teeth. At one locality between River aux Vases and Little Saline creek, Ste. Genevieve county, a poorly preserved fauna of brachiopods and molluscs has been collected, the species represented being as follows:

XX. Fauna of the Bushberg Sandstone Member, Ste. Genevieve County

Brachiopods

Schuchertella ? sp.

Camarotoechia sp.

Delthyris missouriensis Weller

Syringothyris bushbergensis Weller

Spirifer jeffersonensis Weller

Gastropod

Platyceras erectoides Weller

No record of the fauna of the Bushberg sandstone has ever been made in Jefferson county, but collections secured near Sulphur Springs show that the fauna is essentially the same as that of the Glen Park limestone, though the total number of species in the sandstone is smaller.

In the upper black shale the only organic remains observed are a species of *Sporangites*. They appear as minute, discoidal, brown colored bodies, only a fraction of a millimeter in diameter. They are entirely similar to *Sporangites* from the Chattanooga and Ohio shales of Kentucky and Tennessee.

Correlation. Weller^{68b} has pointed out the close similarity of the Glen Park limestone to that collected from the oolitic limestone at Hamburg in Calhoun county, Illinois. Not only are more than one-half of the species of the Glen Park limestone present in the beds at Hamburg, but at least two peculiar genera of brachiopods which have not been recognized anywhere else, are common to these two faunas. The fauna near Hamburg, which has been observed by the writer also in the eastern part of Calhoun county, must be regarded as contemporaneous with that of Glen Park limestone. The Hamburg beds rest disconformably on compact, drab fossiliferous Louisiana limestone. The fauna of the Louisiana has no species in common with the Glen Park. Apparently the Louisiana was deposited in a sea extending southward in the Mississippi valley from the north-

east while the Glen Park was laid down in an entirely different sea that reached northward a short time later from the south.

Two Glen Park species, *Chonetes glenparkensis* and *Tropidodiscus cyrtolites* are reported in the Chouteau limestone, the latter being recorded also from the Northview sandstone and the Rockford limestone. This suggests that there is little in common between these faunas. It is even possible that *C. glenparkensis* which was described from a single water-worn specimen from the Glen Park limestone but described later on the basis of apparently similar specimens from the Chouteau⁷¹ may not actually occur in the Chouteau.

In its lithologic peculiarities and stratigraphic relations, especially as observed south of Kimmswick, the Sulphur Springs formation is strongly suggestive of the Sylamore sandstone of central and southwestern Missouri, northern Arkansas and the Hardin sandstone at the base of the Chattanooga shale of Tennessee. The beds are found immediately overlying an important unconformity. They are quite variably composed lithologically, consisting of quartz sandstone, conglomerate, sandy shale, calcareous shale or limestone, and they contain a more or less abundant amount of dark colored phosphatic material. Scattered through the deposits are the worn teeth of *Ptyctodus* and other fishes. It is doubtful whether these various features are sufficient evidence upon which to correlate the formations as contemporaneous deposits but they appear to be homotaxial equivalents. Since the advance of the sea on the Ozark land during the early Kinderhook was probably a more or less continuous and rapid transgression, the various basal deposits which have been described may be somewhat closely related in time. The Sulphur Springs formation may, with the reservation which has been made, be correlated with these other widespread, somewhat peculiarly characterized deposits.

The black shale overlying the Bushberg sandstone in Ste. Genevieve county is suggestive in its lithologic characters and in its content of *Sporangites*, of the Chattanooga shale of Tennessee. In Ste. Genevieve county the black shale is younger than the Sulphur Springs formation, which, in turn, is younger than the lower portion of the Louisiana limestone. The black shale is therefore certainly Kinderhook, unless the Louisiana limestone is improperly referred to that division.

SUMMARY

The Kinderhook of southeastern Missouri consists of (1) a locally developed black shale (Chattanooga ?) and (2) the thin, discontinuous Sulphur Springs formation composed of brown sandstone, oolitic and impure limestone and sandy shale. The latter is found only locally in northeast Jefferson county and eastern Ste. Genevieve county, its exposed thickness varying from less than 2 feet to nearly 30 feet.

The oolitic Glen Park limestone member is the most fossiliferous part of the formation and has yielded an interesting fauna. The Glen Park limestone unconformably overlies the Louisiana limestone in Calhoun county, Illinois. Lithologically and stratigraphically the Sulphur Springs formation is closely related to the Sylamore sandstone of central and southwestern Missouri and northern Arkansas. These formations may be correlated as homotaxial equivalents.

The black shale above the Sulphur Springs formation corresponds in lithologic character and content of *Sporangites* to the Chattanooga shale of Tennessee, northern Arkansas, and southwest Missouri.



A. Grand Falls, Shoal Creek, six miles south of Joplin.



B. "Boone" chert two miles east of Seligman on the Mo. & N. Ark. Ry.

CHAPTER III

THE OSAGE GROUP

INTRODUCTION

Definition. The Osage group comprises the massive, cherty and crinoidal limestone formations which in the Mississippi valley are found overlying the Kinderhook beds. H. S. Williams proposed the term Osage and assigned to the group the Burlington and Keokuk limestones. These are well known, clearly defined stratigraphic divisions of the Mississippian deposits, and their general similarity in lithologic character and conformable succession makes the grouping of them natural and useful. Recent studies of faunal and stratigraphic relations of the Mississippian beds indicate that certain beds which formerly were regarded as upper Kinderhook should be included rather in the Osage group. These beds, believed to be approximately equivalent, appear to mark the initial deposits in the Osage sea. They are the Fern Glen formation, Sedalia limestone, Pierson limestone and St. Joe limestone. Some authors have included in the Osage group the Warsaw formation which next follows the Keokuk and for reasons presented in the discussion of the Warsaw, the writer follows this classification. As defined in this report, therefore, the Osage group in Missouri includes some beds older and younger than the Burlington and Keokuk.

General character. The Osage group is distinctive in lithologic character, being made up almost altogether of limestone which is coarse-grained, crystalline, crinoidal and cherty. Most of the Osage beds are massive. Because of the relative resistance of the formations to erosion, outcrops are commonly marked by prominent cliffs. In southwestern Missouri the Osage limestones form the Springfield platform, bordered on the side facing the Ozark area of older rocks by a well defined escarpment. The limestone beds are in part nearly pure, but some are siliceous, magnesian or contain earthy impurities. The dominant colors are bluish gray, white and light buff. In general the Keokuk limestone is distinctly more blue than the Burlington. The early Osage deposits are distinguished by a finer texture than is commonly found in the Burlington-Keokuk beds. Chert is abundant. It occurs in small or large ellipsoidal or irregular

nodules, lenses or as fairly continuous bands. Some of the chert is light colored and weathers soft and chalky; some is extremely dense and hard, breaking down in sharply angular blocks and slivers; some is dark and flinty. Stylolites are characteristic, especially in the massive, coarse-grained beds of limestone.

As a whole the Osage limestones are rather highly fossiliferous but some of the beds, especially in southwestern Missouri and northern Arkansas, contain few fossils. The massive character of most of the beds makes collection of fossils difficult in many places, even where the rock contains numerous shells. The Osage faunas are readily distinguished from other Mississippian assemblages, mainly by their prolific crinoid element.

Distribution and thickness. The Osage group is well developed in all parts of Missouri where the Mississippian is represented. In the northeastern part of the state the formations correspond closely to the typical development in southeastern Iowa and the total thickness of the group is about 150 feet. The bluffs bordering the Mississippi river flood plain near Hannibal, Louisiana and Clarksville are capped by massive Burlington limestone. Farther south, in Lincoln county, are typical exposures of Keokuk and Burlington. Near St. Louis is the type area of the Fern Glen formation, which is overlain by the higher Osage limestones. The Osage is well represented in Ste. Genevieve and Jefferson counties south of St. Louis. In central Missouri outcrops of Burlington and Sedalia are found along most of the tributary streams north of Missouri river as far west as Columbia, the Keokuk and Warsaw occurring farther north, partly overlapped by the Pennsylvanian formations. The group is well developed in Cooper, Pettis and adjacent counties where the Mississippian is exposed. In the southwestern part of the state a large area is covered by the Osage outcrops, most of the Mississippian of the area belonging to this group. The total thickness of the Osage in southwestern Missouri is approximately 275 feet.

Stratigraphic relations. The Osage group seems in most exposures to follow the Kinderhook conformably. Not infrequently, however, there is evidence of an erosional break at the top of the Kinderhook and when the broader field relations of the basal Osage strata are considered it becomes clear that the group is separated from the Kinderhook in most places by a disconformity. In some areas the Osage rests directly on Ordovician

or other pre-Mississippian deposits, indicating either non-deposition of Kinderhook strata in these places or removal of them before Osage time. The latter interpretation is strongly suggested in certain cases. In the counties north of Missouri river where the Kinderhook is thin and patchy there are evidences of erosion preceding the Osage as shown by irregularities in the contact between the two groups and by local abrupt variations in thickness of the Chouteau limestone which can hardly be assigned to original unevenness. Branson^{4b} recognizes an erosion interval between the Chouteau and Burlington in the region north of Missouri river. It is well shown in a slight but distinct angular conformity at this horizon in western Illinois, and it is probable that the absence of the Chouteau in most of northeastern Missouri indicates removal of beds once present here. Except in southwestern Missouri no evidences of a stratigraphic break within the Osage group have been observed by the writer. The Burlington limestone follows conformably upon the Sedalia limestone in central and northeastern Missouri, upon the Fern Glen formation in eastern and southeastern Missouri, and upon the Pierson in part of southwestern Missouri. The Keokuk rests conformably on the Burlington. In the Joplin district and to the south and southeast deposits of Upper Burlington age appear to be absent, limestone and chert of Keokuk age resting unconformably on the early Osage Reeds Spring ("Lower Burlington") limestone.

In southwestern Missouri there is evidence of an erosion interval succeeding Keokuk deposition. This consists chiefly in sinks formed in the Osage beds and subsequently filled by Warsaw sediments. In places there are accumulations of broken weathered chert at the base of the section assigned to the Warsaw. The generally more clastic character of the Warsaw suggests a change in physical conditions that commonly aids in distinguishing it from the underlying limestones.

Classification. It is convenient to regard the Osage group as made up of four parts: (1) at the base and lying upon Kinderhook or pre-Mississippian rocks is the Fern Glen, Sedalia, Pierson or St. Joe limestone, (2) the gray to buff, strongly crinoidal Burlington limestone, divisible generally into Lower and Upper Burlington, (3) the bluish, crystalline Keokuk and (4) the Warsaw.

The lack of precise information on the interrelations of the formations at the bottom of the Osage group is basis for the

present use of somewhat local names. The Fern Glen, distinguished largely by lithologic as well as faunal characters, is clearly recognized near St. Louis and in adjacent territory to the north and south. The Sedalia limestone appears to occupy a stratigraphic position corresponding to the Fern Glen, carries a related fauna, but is lithologically different. This formation, which is typically developed in central Missouri, extends into the northeastern part of the state and is probably equivalent to the Wassonville limestone of southeastern Iowa. The Pierson limestone overlies the Northview sandstone and shale in southwest Missouri. It probably corresponds to the Sedalia of central Missouri but differs somewhat in lithologic character. The St. Joe limestone resembles the Fern Glen in appearance and faunal character.

The Burlington limestone contains recognizable lithologic and faunal divisions designated respectively as Lower and Upper Burlington. In northeastern and central Missouri the limestone of these two parts is rather similar, the Upper Burlington being merely somewhat thinner bedded and more cherty than the Lower Burlington. The faunal distinctions, especially, among the echinoderms, are very well marked.

The Keokuk limestone is distinguished lithologically and faunally from the underlying Burlington. In much of southwestern Missouri, and accordingly to Ulrich in southeastern Missouri, it is separated by a disconformity from the underlying beds.

The Warsaw formation resembles the Keokuk in general lithology but it is somewhat more shaly. Distinction is based chiefly on faunal characters.

In southwestern Missouri and adjoining portions of neighboring states all of the Osage strata are classed together under the designation Boone formation. Owing to lithologic similarity and corresponding lack of differentiation in topographic expression, this is a convenient and useful stratigraphic partition. On paleontologic evidence, and in part on lithologic characters, the Boone may be subdivided into the following members: (1) St. Joe limestone (Fern Glen age), (2) Reeds Spring limestone (Fern Glen age), (3) Grand Falls chert (Keokuk age), (4) Limestone and chert (Keokuk age), (5) Short Creek oolite (Warsaw age), and (6) limestone and chert (Warsaw age). Stratigraphic breaks of more or less importance are recognized between the Reeds Spring and Grand Falls members, and between

No. 4 and Short Creek members. The members of the Boone formation numbered above are described in connection with the subdivisions of corresponding age in other parts of Missouri: the St. Joe with other early Osage deposits, the Reeds Spring with Burlington, the Grand Falls and No. 4 with Keokuk, and the Short Creek and No. 6 with Warsaw.

Limestone identified as Upper Burlington is found near Mt. Vernon, in Lawrence county; Crane, in Stone county; Springfield and elsewhere in Greene county. This limestone, absent farther southwest, is intercalated between the Reeds Spring limestone and strata of Keokuk age. If the term Boone is extended to areas where Upper Burlington beds occur, these should be distinguished as a separate member, but it is preferable not to use Boone northeast of Crane and Mt. Vernon.

EARLY OSAGE FORMATIONS

Fern Glen Formation*

General character. The Fern Glen formation was first described by Weller⁶⁹ from exposures at Fern Glen, Missouri, a short distance west of St. Louis. It consists of light bluish gray or slightly greenish limestone, reddish and mottled green and red limestone, and limy shale. Greenish shale partings commonly occur between the limestone beds which range in thickness from a few inches to a foot or more. Scattered fine crinoidal fragments give part of the rock a granular appearance. The lower part is non-cherty but near the top there are in places numerous thin bands of chert.

Everywhere in southeastern Missouri and in the type region the Fern Glen rests unconformably on older rocks ranging in age from the Kimmswick (Ordovician) to the Sulphur Springs (Kinderhook). North of St. Louis near Grafton, Illinois, the Fern Glen is found with typical lithologic and faunal characters. It contains here some beds of crinoidal limestone like those in the typical Burlington. Traced northward the crinoidal phase gradually increases in prominence while the greenish and reddish,

*Subsequent to the submitting of this report, the writer had opportunity, in April, 1928, to examine typical exposures of the Fern Glen near Kimmswick in Jefferson county, south of St. Louis. Numerous fossils were secured from the shale and limestone beds. The most significant observation was the striking resemblance of the dense cherty limestone overlying the reddish shale to the Reeds Spring limestone of southwest Missouri. Many of the peculiarities of the cherty beds in these two regions are identical, and fossils obtained strongly support the conclusion that they are the same. Somewhat shaly beds at the base of the cherty zone were apparently placed by Doctor Weller in the Fern Glen and the remainder in the Burlington.

shaly material disappears. These observed relations strongly indicate the relationship of the formation with the Burlington. The basal division of the Fern Glen in this area is a soft yellowish to light buff magnesian limestone that apparently corresponds to the Sedalia limestone as recognized farther north in western Illinois and in northeastern Missouri. The contact between this limestone and the Chouteau is very well exposed in a number of places and shows not only irregularities due to erosion of the Chouteau but beveling of gentle folds that are present in this Kinderhook formation.

Distribution and thickness. The Fern Glen is known only in the general vicinity of St. Louis, extending about 25 miles north of the city, and southward to the mouth of Establishment creek and the Little Saline region, Ste. Genevieve county. Weller^{69b} states that the red material which typically occurs at this horizon is found in a well at Chester, Illinois, 55 miles southeast of St. Louis and it is probable that the formation was once, and under cover may now be, continuous with the St. Joe limestone in northern Arkansas. The formation cannot be traced farther north than Grafton, Illinois, and it is unknown in northeastern Missouri. A former extent southwest of St. Louis as far as Rolla is indicated by Bridge's^{5a} discovery of a residual Fern Glen fossiliferous boulder in Phelps county. The average thickness of the Fern Glen formation is 30 to 40 feet.

Stratigraphic sections and faunal character. The Fern Glen was examined by the writer at its type locality, just west of Fern Glen station on the Missouri Pacific Railroad, 20 miles west of St. Louis. Weller's section at this place is as follows:

(28) Section of the Fern Glen Formation at Fern Glen, St. Louis County

	Thickness Feet. Inches:
Osage group	
Burlington limestone (Lower)	
5. Limestone, gray with an abundance of chert; outcrops mostly covered with soil and talus.....	25
Fern Glen formation	
4. Shale, greenish, calcareous, with an abundance of chert in bands that are more or less continuous. Toward the base the beds are somewhat variegated with the red color of the sub-jacent bed.....	14
3. Shale, red, calcareous, highly fossiliferous, a persistent 6-inch chert band at the top, less conspicuous more or less continuous chert bands occasionally in middle.....	12
2. Limestone, red, more or less crystalline, contains numerous crinoid stems and other fossils similar to bed above.....	14
1. Limestone, buff, hard, tough, exposed.....	2
Total Fern Glen exposed.....	42

A section measured by Weller near Kimmswick, 20 miles south of St. Louis, shows essentially the same characters and gives the total thickness of Bed 1 as 6 feet.

Several sections were measured by the writer near Chautauqua, Jersey county, Illinois, about 25 miles north of St. Louis. These show the Fern Glen approximately 50 feet in thickness and composed almost entirely of greenish, cherty and partly shaly, thin bedded limestone. Typical red limestone and shale occurs locally. A section observed at the mouth of Piasa creek, just south of Chautauqua, agreeing closely with a section measured by Weller in this region, is as follows:

(29) Section at Mouth of Piasa Creek, South of Chautauqua, Illinois

		Thickness	
		Feet.	Inches.
Osage group			
Burlington limestone (Lower and Upper, not differentiated)			
11.	Limestone, light gray, coarse-grained, crinoidal, crystalline, cherty, partly concealed.....	125	
10.	Limestone, gray to light buff, fine-grained, chert abundant....	8	
Fern Glen formation			
9.	Limestone, yellowish, silico-magnesian, massive, rather soft, contains bands of hard, dense chert.....	3	6
8.	Limestone, light yellowish to greenish gray, slightly shaly, fine-grained, hard splintery chert very abundant in thin bands.....	5	4
7.	Limestone, like 9, quite soft, weathers as re-entrant in cliff, contains chert bands.....	4	
6.	Limestone, greenish, soft, shaly, with numerous crinoid fragments; hard, dark, flinty chert in bands 2 to 4 inches thick, 6 to 8 inches apart.....	14	
5.	Limestone, red, soft, shaly, contains abundant fossil fragments and some chert.....	2	
4.	Limestone, light green, soft, very shaly, contains fossils....	3	
3.	Limestone, light greenish gray, fine-grained, chert very abundant in thin bands.....	2	
2.	Limestone like 3 but with scattered nodules of hard yellowish white chert.....	5	6
1.	Limestone, yellowish to buff, fine- to medium-grained, sub-crystalline, massive, contains calcite geodes up to 4 inches in diameter, stylolites present. Exposed.....	8	
Total Fern Glen exposed.....		47	

Elsewhere in the Mississippi river bluffs in this vicinity the massive Bed 1 is found to have a thickness of about 15 feet, but near Grafton a thickness of 20 to 23 feet was observed. Here the contact with the thin-bedded, rather nodular dense bluish Chouteau limestone is clear, and broad depressions extending more than 2 feet into the upper surface of the Chouteau are filled by the massive yellowish overlying rock.

The fauna of the Fern Glen formation has been described by Weller.⁶⁹ It is a distinctive one containing a number of

species restricted to this horizon, but showing affinities with the succeeding Osage beds. While many of the Fern Glen fossils are probably descendants of Chouteau forms, few species are identified in both formations, the "Chouteau" affinities pointed out by Weller belonging with the "Upper Chouteau" or as here designated the Sedalia and not with the restricted Chouteau.

XXI. Fauna of the Fern Glen Formation (Weller)

Corals

Cyathaxonia arcuata Weller
Cyathaxonia minor Weller
Zaphrentis cliffordana (E. & H.)
Zaphrentis wortheni Weller
Amplexus rugosus Weller
Amplexus brevis Weller
Beaumontia americana Weller
Favosites valmeyerensis Weller
Cladochonus americanus Weller
Monilopora crassa (McCoy)
Palaeacis depressus (M. & W.)
Palaeacis bifidus Weller

Crinoids

Synbathocrinus dentatus Owen and Shumard
Vasocrinus macropleurus (Hall)
Barycrinus sp.
Poteriocrinus sp.
Coeliocrinus sp.
Graphiocrinus sampsoni Weller
Platycrinus stellatus Weller
Platycrinus springeri Weller
Rhodocrinus punctatus Weller
Agaricocrinus praecursus Rowley
Uperocrinus pistilliformis (M. & W.)
Actinocrinus rubra Weller
Physetocrinus smalleyi Weller
Mespilocrinus sp.
Metichthyocrinus sp.

Blastoid

Penetremites decussatus Shumard

Bryozoans

Fistulipora fernglenensis Weller
Chilotrypa americana S. A. Miller
Cystodictya lineata Ulrich
Evactinopora sexradiata M. & W.

Brachiopods

Crania missouriensis Weller
Leptaena analoga (Phillips)
Schuchertella fernglenensis (Weller)
Orthotetes sp.
Chonetes illinoisensis Worthen
Chonetes logani N. & P.
Productus fernglenensis Weller
Productus sampsoni Weller
Rhipidomella jerseyensis Weller
Schizophoria poststriatula Weller
Camarophoria bisinuata (Rowley)
Rhynchopora persinuata (Win.)
Dielasma fernglenense Weller
Spirifer vernonensis Swallow
Spirifer rowleyi Weller
Brachythyris chouteauensis Weller
Brachythyris fernglenensis (Weller)
Delthyris novamexicana (Miller)
Spiriferina subtexta White
Cyrtina burlingtonensis Rowley
Pseudosyrinx sampsoni (Weller)
Athyris lamellosa (L'Eveille)
Cliothyridina glenparkensis Weller
Cliothyridina obmaxima (McChesney)
Cliothyridina prouti (Swallow)
Ptychospira sexplicata (W. & W.)
Hustedia circularis (Miller) ?

Pelecypods

Aviculopecten fernglenensis Weller
Conocardium sp.

Gastropod

Platyceras paralium W. & W.

Cephalopods

Orthoceras sp.
Cyrtoceras ? sp.

Trilobite

Proetus fernglenensis Weller

Sedalia Limestone

General character. The name Sedalia limestone is here proposed for the gray to light buff "silico-magnesian" limestone which was termed the Upper Chouteau by Swallow^{51a} and other geologists.^{7, 37, 58} In the words of Swallow who first distinguished the horizon, the "Upper Chouteau" (Sedalia) limestone is a "brownish-gray, earthy, silico-magnesian limestone in thick beds, which contain disseminated masses of white or limpid calcareous spar." The formation is really a siliceous dolomite throughout the region of its typical development. An analysis reported by Swallow from a sample taken at Chouteau Springs, Cooper county, shows calcium carbonate (CaCO_3) 48.23 per cent, magnesium carbonate (MgCO_3) 34.93 per cent, silica (SiO_2) 13.90 per cent, alumina and iron, 2.01 per cent, total 99.07 per cent. Specimens of the formation from the vicinity of Sedalia have been found to contain as much as 17.69 per cent of silica and retaining essentially the magnesium carbonate content reported in other samples.^{9e}

The Sedalia is massively bedded, individual layers being in many places 10 to 20 feet in thickness. These massive beds weather in rather smooth, characteristically rounded surfaces unlike either the Chouteau or the Burlington. The rock is somewhat soft on fresh exposure and breaks with an even or subconchoidal fracture. On exposed surfaces it appears locally to be much harder, though this is not a universal peculiarity. At different horizons in the formation layers of grayish or bluish black, very dense, hard chert nodules are commonly found which range in size from 2 to 12 inches in length, 1 to 6 inches in width and 1 to 3 inches in thickness. Locally there are nearly continuous thin chert bands. The dark, flinty chert nodules typically possess an outer rim of white cherty material.

Distribution and thickness. The Sedalia limestone is most typically developed in the central Missouri region in Pettis, Cooper, Howard and Boone counties, where exposures in quarries and the bluffs of various streams are numerous. Eastward toward Mississippi river exposures are not so abundant but the formation is fairly continuous into Lincoln and St. Louis counties. On the east side of Mississippi river in Jersey, Calhoun and Pike counties, Illinois, it is well developed and may be observed with all characteristic features in the bluffs of Mississippi river as far north as Kinderhook. The magnesian layer (Bed 7) of the Mississippian section at Burlington, is regarded as the

equivalent of the Sedalia limestone although it differs somewhat in lithologic character.

In thickness the Sedalia ranges from a minimum of practically nothing to a maximum of about 40 feet in the central portion of the state. In the northeastern part of Missouri the thickness of the formation is nearly constant averaging about 10 to 15 feet. The magnesian limestone (Bed 7) at Burlington, Iowa, is about 3 to 5 feet.

Stratigraphic relations. In quarries near Sedalia, at Sweeney, and other good exposures in central Missouri this limestone is commonly underlain by the Chouteau limestone (restricted) and overlain by Lower Burlington limestone. East of Boone county the Chouteau, which is locally reduced in thickness by reason of post-Kinderhook erosion, is overlain by soft, yellowish to buff, magnesian, massive, chert-bearing Sedalia limestone followed by the Burlington. In other places the Sedalia rests unconformably on Callaway, Snyder Creek or older rocks. In much of northeastern Missouri the true Chouteau is absent, but bluish gray to buff "Upper Chouteau" carrying the fauna of the central Missouri Sedalia is present. The Sedalia is recognizable persistently in the Mississippi bluffs as a soft, yellow to buff magnesian limestone that commonly forms a recession in the cliff face beneath projecting massive crinoidal Burlington limestone.

In the region where the Sedalia limestone is present no Fern Glen beds are found, and in the district where the Fern Glen appears no Sedalia is recognized. This mutually exclusive relation, coupled with likeness in stratigraphic position, and as will be noted, certain faunal characters, strongly suggests at least approximate equivalence. In this connection sections studied in southern Jersey county, Illinois, north of St. Louis, are instructive. As shown in section 29 reported on page 147 there are found in the Fern Glen as recognized in this district several beds which exhibit lithologic features typical of the Sedalia interbedded with the characteristic red and greenish shaly strata of Fern Glen type carrying Fern Glen fossils. The lower thick, massive bed in particular appears to persist northward and may represent the Sedalia; in the upper part of the Fern Glen some coarse-grained, crinoidal limestone layers are intercalated and northward these replace the finer grained greenish and yellowish layers. Thus laterally the Sedalia appears to grade into Fern Glen but it is not certain whether the former

is equivalent to all of the latter or, as seems probable, only to the lower part.

Stratigraphic sections and faunal character. The Sedalia is exposed at numerous points in the vicinity of Sedalia where it is one of the most easily recognized formations, but the complete thickness is seldom observed in a single locality. A number of quarries near Sedalia secure stone very largely from this formation. At the Rymer Brothers quarry two miles north of the city the following section was measured:

(30) Section on Georgetown Road, 1 Mile North of Sedalia, Pettis County

	Thickness Feet. Inches.	
Residual clay and soil.....	3	
Osage group		
Sedalia limestone		
3. Limestone, light blue to yellow, dolomitic, siliceous, evenly textured, very massive. Occasional calcite geodes and irregular chert nodules and layers.....	15	
2. Limestone, light bluish, fine granular, massive, showing a slight color mottling. Chert bands 2 to 3 inches thick at top.	3	
Kinderhook group		
Chouteau limestone		
1. Limestone, light to dark bluish drab, dense, compact, in thin, rather uneven, nodular bands, with numerous fossils.....	6	6

Outcrops are observed along the streams of Pettis, Saline and Cooper counties, one of the best of which is that on LaMine river in the southwest corner of Cooper county at the large quarry operated by the Missouri, Kansas & Texas railroad at Sweeney, two and one-half miles north of Clifton City. This section which includes not only a complete exposure of the Chouteau but the lower portion of the Burlington as well shows the Sedalia with a total thickness of 43 feet. The section which may be regarded as the type for the formation, is as follows:

(31) Section at Sweeney, Cooper County. Sec. 4, T. 46 N., R. 19 W.

	Thickness Feet. Inches.	
Osage group		
Burlington limestone (Lower)		
19. Limestone, bluish gray, coarse crystalline, crinoidal, very massively bedded.....	35	
Sedalia limestone		
18. Limestone, light bluish to bluish gray, fine-grained, uniform, lower part thin bedded, upper part massive, upper surface very even. Contains fossils.....	3	1
17. Shale, light bluish to yellowish, calcareous, sandy, especially toward bottom.....		11
16. Limestone, light blue, lighter and more greenish than beds below, arenaceous. Appears to rest with slight disconformity upon the eroded surface of the subjacent limestone. Greatest thickness.....	1	6

		Thickness	
		Feet.	Inches.
15.	Limestone, light blue when fresh weathering to brown, dolomitic and siliceous, very massive, uniform texture, fracture subconchoidal. Marked by fine stylolites at intervals. The upper surface apparently eroded and markedly uneven to the extent of 9 inches.....	2	3
14.	Shale parting, dark bluish.....		½
13.	Limestone like 15 with large chert bluish black flinty nodules with thin white rims, larger in size in the lower part of the bed.....	6	8
12.	Shale, calcareous, a prominent parting on weathered surface.		1
11.	Limestone and chert like 13. The chert occurs in nodules and irregular, discontinuous bands throughout the zone. It is very fossiliferous, especially in the upper part, being crowded with the remains of bryozoans and other fossils....	9	3
10.	Shale parting.....		½
9.	Limestone like 15.....		8
8.	Chert, white, in thin, continuous band. The chert resembles a very siliceous limestone rather than the dark flint, and contains many poorly preserved bryozoans and other fossils.		¾
7.	Limestone, like 15. Very massively bedded. Marked by innumerable fine, horizontal lines which on weathering stand out in relief because of greater resistance to erosion..	15	
6.	Chert, dark bluish, flinty, in thin persistent band.....		3
5.	Limestone, like 15.....	1	10
4.	Shale parting.....		2
3.	Limestone like 15.....	1	9
Kinderhook group			
Chouteau limestone			
2.	Limestone, bluish drab, very compact, dense, fine-grained, breaking with conchoidal fracture.....	25	8
Sylamore sandstone			
1.	Sandstone, light green, calcareous, shaly.....		2-5
Devonian limestone			

Fossils collected from the Sedalia at Sweeney are listed in faunal table XXII.

In Saline county the Sedalia limestone appears in the bluffs of Blackwater river just above the mouth of Salt Fork, and it is exposed at intervals to a point west of Ferris creek in the south central part of the county.

Near Warsaw the Sedalia limestone is apparently represented by 9½ feet of bluish gray to yellowish brown, soft, massive, fine-grained magnesian limestone that overlies the Chouteau. This horizon is well exposed in Kiesinger Bluff north of the town (see section 26). Fossils collected here are recorded in faunal table XXII.

The Sedalia limestone is exposed in the bluffs of Missouri river in western Howard county as shown by the following section measured one and one-half miles north of Lisbon (Sec. 12, T. 50 N., R. 18 W.). Fossils collected at this locality are listed in the Sedalia faunal table.

(32) Section on Sanford Tippet Farm, North of Lisbon, Howard County.
Sec. 12, T. 50 N., R. 18 W.

		Thickness	
		Feet.	Inches.
Osage group			
Burlington limestone (Lower)			
6.	Limestone, gray, coarse crystalline, crinoidal, massively bedded (partly concealed).....	30	
Sedalia limestone			
5.	Limestone, brown, magnesian, fine- to medium-grained containing scattered coarse crinoid fragments; hard and massive in lower part, soft and shelly in upper part.....	5	
4.	Limestone, light brownish to bluish gray, dolomitic and siliceous, fine granular, very uniform in texture. Beds from 6 inches to 5 feet in thickness, tending to weather along joints obliquely inclined to the surface. Calcite geodes common. Chert in nodules.....	11	
3.	Limestone, bluish, fine-grained, dense, somewhat magnesian, thin irregular beds.....	1	6
2.	Limestone like 4.....	9	6
Kinderhook group			
Chouteau limestone			
1.	Limestone, bluish drab, dense, compact, breaking with a very sharply conchoidal fracture, bedding thin and somewhat irregular.....	55	

The Sedalia is well exposed in the Missouri river bluffs near Providence and Easley, Boone county (see sections 15, 16). Fossils collected at Easley are recorded in the Sedalia faunal table. Farther east the Sedalia is recognized in most places where the proper horizon is exposed. A section observed near Fulton, in Callaway county, is as follows:

(33) Section in Dark Hollow, 3 Miles Southeast of Fulton, Callaway County.
Sec. 28, T. 47 N., R. 9 W.

		Thickness	
		Feet.	Inches.
Osage group			
Burlington limestone (Lower)			
7.	Limestone, light gray, medium-grained, sub-crystalline, hard, massive. Exposed.....	2	
6.	Limestone, gray to white, coarse-grained, crinoidal, tends to crumble on weathering, massive.....	21	6
Sedalia limestone			
5.	Limestone, brown, magnesian, medium- to fine-grained, rather hard, compact below, soft above, contains scattered crinoid fragments, very massive.....	17	
4.	Covered.....	?	
3.	Limestone, buff, fine-grained, dolomitic, soft and porous, but massive, crumbles to powder when struck with hammer....	5	6
2.	Limestone, buff to greenish brown, fine-grained, thin-bedded below becoming more massive above, contains fossils.....	3	
Disconformity ?			
Kinderhook group			
Chouteau limestone ?			
1.	Limestone, bluish drab, subcrystalline, medium-grained, hard, somewhat variable in character, weathering in nodular surfaces, thin-bedded. No fossils observed. Exposed.....	1	6

Bed 2 of this section contains *Batocrinus* sp., *Rhipidomella* sp., *Spiriferina subtexta* White, *Spirifer grimesi* Hall ? *S. shepardi* Weller ?, *S. louisianensis* Rowley, and *Brachythyris suborbicularis* (Hall) ?.

The Sedalia limestone was observed at several places near Montgomery City, resting unconformably upon the Chouteau (see section 18). Collections of fossils from beds 2 and 3 at the Grenen quarry are recorded in Faunal Table XXII.

Throughout the northeastern Missouri region the Sedalia is commonly represented by massive but generally soft, yellowish to buff, magnesian limestone. It is described in sections 4 to 10, pages 71-74. Fossils collected at Clarksville, Hannibal (Lovers Leap), on Noix creek near Bowling Green (Bed 5 of section 7), and on Little Fabius river near Newark, Knox county, are reported below in the faunal table.

At Burlington, Iowa, Bed 7, consisting of soft, buff to brownish dolomitic limestone, 5 feet thick, corresponds to the Sedalia as described in the Mississippi river bluffs in northeastern Missouri, western Illinois, and to the west. Its fauna, as reported by Van Tuyl⁵⁹ is listed in Table XXII.

As a whole, the Sedalia formation is distinguished by species of corals, bryozoans and brachiopods which are not found in the underlying Chouteau limestone. On the other hand many of the characteristic Chouteau fossils have not been found in the Sedalia, although some species that are widespread and common in the Chouteau occur rarely in the higher beds.

XXII. Fauna of the Sedalia Limestone

Localities	Sweeney, Beds 3-15	Sweeney, Beds 16-18	Kiesinger Bluff, Warsaw	Lisbon, Bed 3	Lisbon, Bed 4	Lisbon, Bed 5	Easley	Montgomery, Bed 2	Montgomery, Bed 3	Clarksville	Hannibal	Bowling Green	Newark, Bed 1	Newark, Bed 2	Burlington, Ia., Bed 7
<i>Corals</i>															
<i>Cyathaxonia tantilla</i> (Miller).....	x	-	-	-	-	-	-	-	-	?	-	-	-	-	-
<i>Zaphrentis tenella</i> Miller.....	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Zaphrentis exigua</i> Miller.....	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Zaphrentis</i> sp.....	-	-	x	-	x	2	-	x	x	x	-	x	-	-	x
<i>Amplexus blairi</i> Miller.....	x	-	-	-	-	-	?	-	-	-	-	?	-	-	-
<i>Amplexus</i> sp.....	-	x	-	x	-	-	-	-	-	-	-	-	-	-	-
<i>Homalophyllum calceolum</i> White.....	-	-	x	-	-	-	-	-	-	-	x	-	-	-	-
<i>Chonophyllum sedaliense</i> White.....	-	x	x	-	-	-	-	-	-	-	-	-	-	-	-
<i>Hadrophyllum</i> sp.....	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-
<i>Cyathophyllum glabrum</i> Keyes.....	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-
<i>Syringopora harveyi</i> White.....	-	-	-	-	-	-	?	-	-	-	-	?	-	-	?
<i>Leptopora typa</i> Winchell.....	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x
<i>Monilopora</i> sp.....	-	-	-	-	-	x	-	-	-	-	-	-	x	-	-
<i>Blastoids</i>															
<i>Schizoblastus sampsoni</i> (Hambach)....	x	-	-	x	-	-	-	-	-	-	-	-	-	-	-
<i>Schizoblastus roemeri</i> (Shumard).....	-	-	-	-	-	-	x	-	-	-	-	x	-	-	-
<i>Lophoblastus conoideus</i> Rowley.....	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-

Localities	Sweeney, Beds 3-15	Sweeney, Beds 16-18	Kiesinger Bluff, Warsaw	Lisbon, Bed 3	Lisbon, Bed 4	Lisbon, Bed 5	Easley	Montgomery, Bed 2	Montgomery, Bed 3	Clarksville	Hannibal	Bowling Green	Newark, Bed 1	Newark, Bed 2	Brlington, Ia., Bed 7
<i>Crinoids</i>															
Batocrinus sp.	-	-	-	-	-	x	-	-	-	-	-	-	-	-	-
Actinocrinus sp.	-	x	-	-	-	x	-	-	-	-	-	-	-	-	-
Platycrinus acclivus Miller ?	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-
Platycrinus sp.	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-
Stems and fragments	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
<i>Bryozoans</i>															
Leioclema sp.	x	-	-	-	-	x	-	-	-	-	-	-	-	-	-
Fenestella sp.	4	x	-	2	-	4	-	3	4	-	-	-	4	3	x
Fenestella rudis Ulrich	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-
Pinnatopora sp.	x	-	-	-	-	-	-	x	-	-	-	-	x	-	-
Rhombopora sp.	x	-	-	2	-	-	x	x	2	-	-	-	-	-	-
Ptilopora sp.	x	-	-	-	-	-	x	-	-	-	-	-	-	-	x
Cystodictya sp.	-	-	-	-	-	-	-	-	x	x	-	-	-	-	x
<i>Brachiopods</i>															
Leptaena analoga (Phillips)	x	-	-	-	-	-	-	-	x	-	x	x	-	-	-
Leptaena convexa Weller	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x
Schuchertella fernglenensis (Weller) ?	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-
Schuchertella sp.	-	-	-	-	-	-	-	-	2	x	-	-	-	-	-
Schellwienella inaequalis (Hall)	-	-	-	-	-	-	-	-	-	?	-	-	-	-	x
Schellwienella inflata (W. & W.) ?	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x
Schellwienella sp.	-	-	2	-	x	-	-	-	2	x	x	x	?	-	x
Chonetes logani N. & P.	x	-	x	-	-	-	-	x	x	x	-	-	-	-	x
Chonetes illinoisensis Worthen	-	-	x	-	-	?	-	-	-	x	?	-	?	-	x
Chonetes multicostus Winchell	-	-	-	-	-	-	-	x	x	x	-	-	-	-	x
Chonetes sp.	2	-	-	x	x	-	-	-	-	-	-	x	-	-	x
Productus sampsoni Weller	x	-	-	x	-	-	-	-	-	-	-	-	x	x	x
Productus sedaliensis Weller	x	-	?	-	-	-	-	-	-	-	-	-	-	-	-
Productus fernglenensis Weller	-	-	?	-	-	-	-	-	-	-	-	-	-	x	-
Productus ovatus Hall	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-
Productus sp.	-	-	-	-	-	2	-	x	2	-	x	-	x	x	x
Pustula concentrica (Hall)	x	-	x	-	x	-	-	-	x	-	-	-	-	-	x
Pustula morbilliana (Winchell)	-	-	-	-	-	-	-	-	-	-	x	-	?	?	-
Pustula laevicula Moore	-	-	x	-	-	-	-	-	-	-	x	?	x	-	-
Pustula alternata (N. & P.) ?	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-
Pustula sp.	-	x	x	-	x	-	-	-	-	-	-	-	-	-	-
Rhipidomella diminutiva Rowley	-	-	-	-	-	-	-	-	x	-	?	-	-	-	-
Rhipidomella thiemei (White)	-	-	-	-	-	-	-	-	-	?	-	x	-	-	x
Rhipidomella jerseyensis Weller ?	-	-	-	-	-	-	x	-	-	-	x	-	-	-	-
Rhipidomella burlingtonensis (Hall)	-	-	?	-	-	-	-	-	-	x	x	-	-	-	-
Schizophoria sedaliensis Weller	?	x	?	-	-	-	-	?	?	-	?	?	-	?	-
Schizophoria poststriatula Weller	-	-	-	-	x	-	-	-	-	x	-	-	-	-	-
Camarotoechia chouteauensis Weller	?														

FAUNAL TABLE XXII—Continued.

Localities	Sweeney, Beds 3-15	Sweeney, Beds 16-18	Kiesinger Bluff, Warsaw	Lisbon, Bed 3	Lisbon, Bed 4	Lisbon, Bed 5	Easley	Montgomery, Bed 2	Montgomery, Bed 3	Clarksville	Hannibal	Bowling Green	Newark, Bed 1	Newark, Bed 2	Burlington, Ia., Bed 7
<i>Brachiopods—Cont'd</i>															
<i>Camarotoechia</i> sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Camarophoria bisinuata</i> (Rowley)	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-
<i>Shumardella missouriensis</i> (Shumard) ..	x	x	-	x	-	x	x	-	-	-	-	-	-	x	-
<i>Shumardella obsoletus</i> (Hall)	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-
<i>Rhynchopora persinuata</i> (Winchell)	-	-	-	-	-	-	-	-	-	-	x	-	x	-	x
<i>Rhynchopora</i> ? <i>cooperensis</i> (Shumard) .	?	-	x	-	-	-	-	-	x	?	-	-	-	-	-
<i>Centronelloidea rowleyi</i> (Worthen)	-	-	x	-	-	-	-	-	-	-	x	-	-	-	-
<i>Cranaena globosa</i> Weller	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Cranaena</i> sp.	x	-	-	-	x	-	-	-	-	-	x	-	-	-	-
<i>Dielasma burlingtonense</i> (White) ?	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x
<i>Dielasma</i> sp.	-	-	-	-	-	-	-	-	?	x	x	-	-	-	-
<i>Delthyris novamexicana</i> (Miller)	-	-	x	-	x	-	-	-	-	-	x	-	-	-	-
<i>Spiriferina subtexta</i> White	x	-	-	-	-	-	-	-	-	x	x	-	?	?	-
<i>Spiriferina solidirostris</i> White	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x
<i>Cyrtina burlingtonensis</i> Rowley	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-
<i>Spirifer forbesi</i> N. & P.	-	-	x	-	-	-	-	-	-	-	-	-	-	-	x
<i>Spirifer louisianensis</i> Rowley	x	x	-	?	x	-	x	-	-	-	-	x	-	x	-
<i>Spirifer missouriensis</i> Swallow	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Spirifer osagensis</i> Swallow	-	x	-	-	-	-	-	-	-	x	-	-	-	-	-
<i>Spirifer gregeri</i> Weller	-	-	x	-	-	-	x	x	x	x	-	-	-	-	-
<i>Spirifer piersonensis</i> Moore	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-
<i>Spirifer grimesi</i> Hall	-	-	-	-	?	-	-	-	x	-	x	-	-	-	x
<i>Spirifer vernonensis</i> Swallow	-	-	-	-	x	-	?	-	-	-	-	-	-	-	-
<i>Spirifer shepardii</i> Weller ?	-	-	-	-	-	-	x	-	-	-	-	-	-	-	-
<i>Spirifer rowleyi</i> Weller ?	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-
<i>Spirifer platynotus</i> Weller	-	-	-	-	-	-	-	-	-	x	x	-	-	-	x
<i>Spirifer insculptus</i> Rowley	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-
<i>Spirifer incertus</i> Hall ?	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-
<i>Spirifer</i> sp. cf. <i>S. mundulus</i> Rowley	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x
<i>Spirifer</i> sp. cf. <i>S. legrandensis</i> Weller ...	-	-	-	-	-	-	-	-	-	x	-	-	-	-	-
<i>Spirifer</i> sp.	-	-	x	-	-	-	-	-	x	3	x	x	x	x	-
<i>Brachythyris chouteauensis</i> (Weller) ...	?	?	x	-	x	-	-	?	x	x	-	-	-	-	-
<i>Brachythyris fernglenensis</i> Weller ?	-	-	x	-	-	-	x	-	x	x	-	-	-	-	-
<i>Brachythyris</i> sp.	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-
<i>Syringothyris</i> sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x
<i>Pseudosyrinx missouriensis</i> Weller	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-
<i>Pseudosyrinx sampsoni</i> (Weller)	-	-	-	-	-	-	-	-	x	-	-	-	-	-	-
<i>Spiriferella</i> ? <i>schucherti</i> (Rowley)	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-
<i>Rowleyella fabulites</i> (Rowley) ?	-	-	-	-	-	-	-	x	-	-	-	-	-	-	-
<i>Ambocoelia levicula</i> Rowley	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-
<i>Ambocoelia parva</i> Weller	x	-	-	-	-	x	-	-	-	-	-	-	-	-	-
<i>Reticularia cooperensis</i> (Swallow)	x	-	-	x	-	x	-	-	-	-	-	x	?	-	x

PIERSON LIMESTONE

General character. The Pierson limestone was named by Weller⁶⁶ from Pierson Creek near Springfield. The formation was described by Shepard⁴² under the designation Chouteau limestone. The Pierson is typically a fine-grained, buff, more or less gritty limestone, ranging in thickness up to about 30 feet. It appears to correspond to the "Upper Chouteau" of central Missouri. However, in the region where it is typically developed, the formation is found resting upon the Northview sandstone and shale, while a limestone (Compton) carrying a Chouteau fauna and resembling that formation in lithologic character is found beneath the Northview. To the north limestone classed as Chouteau appears beneath the Pierson.

In some exposures the Pierson is rather unfossiliferous, but in others fossils are common. Weller describes a locality on Little Sac river about two miles north of Lyman station on the St. Louis and San Francisco railroad where a collection was made by him. The species are recorded in Faunal Table XXIII. A collection was made by the writer in the valley of Little Sac river on the Springfield-Buffalo highway. Twenty feet of the Pierson may be seen here, resting on the Northview.

The Pierson limestone was not traced in the course of the writer's work so as to determine its relations to the St. Joe limestone which appears in southern Greene county and farther south. The Pierson, Chouteau, Northview and Compton are not known in the region where the St. Joe limestone appears.

XXIII. Fauna of the Pierson Limestone

Localities*	A	B
<i>Corals</i>		
<i>Zaphrentis tenella</i> Miller.....	—	x
<i>Zaphrentis</i> sp.....	x	—
<i>Amplexus blairi</i> Miller ?.....	—	x
<i>Bryozoans</i>		
<i>Fenestella</i> sp. 1, 2.....	—	x
<i>Polypora</i> sp.....	—	x
<i>Cystodictya</i> sp.....	—	x
<i>Brachiopods</i>		
<i>Leptaena analoga</i> (Phillips).....	x	x
<i>Schuchertella</i> ? sp.....	—	x
<i>Schellwienella</i> sp. cf. <i>S. inflata</i> (W. & W.).....	x	—
<i>Streptorhynchus tenuicostatus</i> Weller.....	—	x
<i>Chonetes missouriensis</i> Weller.....	x	x

FAUNAL TABLE XXIII—Continued.

Localities*	A	B
<i>Brachiopods—Cont'd</i>		
Chonetes logani N. & P.	x	—
Chonetes glenparkensis Weller.	—	x
Chonetes sp.	—	x
Productus arcuatus Hall.	x	—
Productus fernglenensis Weller.	x	x
Productus ovatus Hall.	x	x
Productus sedaliensis Weller.	—	x
Productus sampsoni Weller.	—	x
Productus sp.	—	x
Pustula concentrica (Hall) ?	—	x
Pustula n. sp.	x	—
Pustula sp.	—	x
Rhipidomella diminutiva Rowley.	x	x
Schizophoria poststriatula Weller.	x	?
Schizophoria sedaliensis Weller.	—	x
Shumardella missouriensis (Shumard).	—	x
Rhynchotetra elongata Weller.	x	—
Rhynchopora persinuata (Winchell).	x	x
Rhynchopora ? cooperensis (Shumard) ?	—	x
Cranaena sp.	—	x
Dielasma chouteauense Weller.	—	x ^o
Dielasma fernglenense Weller.	—	x
Dielasma sp.	x	—
Spiriferina subtexta White.	—	x
Delthyris novamexicana (Miller).	—	x
Spirifer rowleyi Weller ?	—	x
Spirifer striatiformis Meek.	—	x
Spirifer shepardii Weller.	x	x
Spirifer osagensis Swallow.	—	x
Spirifer louisianensis Rowley.	x	x
Spirifer piersonensis Moore.	—	x
Spirifer sp.	x	x
Brachythyris chouteauensis (Weller).	x	x
Syringothyris sp.	—	x
Reticularia cooperensis (Swallow).	x	—
Ambocoelia parva Weller.	—	x
Athyris lamellosa (L'Eveille).	x	—
Cliothyridina tenuilineata (Rowley) ?	—	x
Cliothyridina prouti (Swallow) ?	x	cf.
<i>Pelecypods</i>		
Edmondia ? sp.	—	x
Parallelodon sp.	x	—
Pterinopecten sedaliensis Miller.	—	x
Pterinopecten cooperensis (Shumard).	—	x
<i>Gastropods</i>		
Euomphalus sp.	—	x
Platyceras nasutum Miller.	—	x
Orthonychia sp.	—	x

FAUNAL TABLE XXIII—Continued.

Localities*	A	B
<i>Cephalopods</i>		
Orthoceras sp.....	x	—
Nautilus ? sp.....	x	—
<i>Trilobite</i>		
Phillipsia sampsoni Vogdes ?.....	—	x

*A. On Little Sac Creek, north of Lyman, Greene County.

B. On Springfield-Buffalo road in Little Sac Valley.

ST. JOE LIMESTONE

General character. In Christian, Barry, Stone and McDonald counties, southwestern Missouri, and throughout a wide area in northern Arkansas, the lowermost Mississippian limestone is a light blue to greenish, locally partly red, fine to medium-grained, rather evenly bedded deposit known as the St. Joe limestone. This limestone, which was named by Branner³ from the town of St. Joe in Searcy county, north central Arkansas, has been classed by the state and federal geological surveys as the bottommost member of the Boone formation. It is distinguished from the overlying beds by general absence of chert and by its fauna. Shaly partings occur commonly between the beds and in places there are intercalated beds of calcareous shale. In many exposures fossils are scarce, though crinoid fragments and other comminuted organic remains give to the rock a distinctly granular appearance, especially on weathered outcrops. Locally fossils are well preserved and abundant.

Where the Chattanooga shale is present, as in McDonald county and throughout most of northwestern Arkansas, the St. Joe limestone rests upon it disconformably. Elsewhere in southwestern Missouri the St. Joe is generally found overlying Ordovician dolomite, Kinderhook beds being absent. In eastern Arkansas the formation is reported to occur unconformably above St. Clair (Silurian) limestone, St. Peter (Ordovician) sandstone or the Iizard, Kimmswick or Fernvale (Ordovician) limestones. The thickness of the St. Joe limestone ranges commonly from 25 to 40 feet.

The fauna of the St. Joe limestone appears to be distinctly younger than the Chouteau or other Kinderhook faunas. Like

the Fern Glen, it is more closely allied with the Burlington fauna of Missouri and Iowa.

Stratigraphic sections and paleontologic character. The northernmost exposures of typical St. Joe limestone examined by the writer are located in the vicinity of Reeds Spring, Stone county, southeast of Galena. Along the Missouri Pacific Railroad southeast of Reeds Spring station, several cuts show good sections of the lower Mississippian rocks. The total thickness of the St. Joe limestone is about 35 feet. Following is a composite section of exposures between 1 and 2 miles southeast of the town:

(34) Section Along Missouri Pacific Railroad Southeast of Reeds Spring, Stone County

		Thickness	
		Feet.	Inches.
Osage group			
Boone formation			
Reeds Spring limestone member			
9.	Limestone and chert, the limestone blue, very compact, fine-grained, subcrystalline, in thin beds alternating with dark flinty bands of chert. Exposed.....	37	
St. Joe limestone member			
8.	Limestone, light bluish gray with slight greenish cast, medium- to fine-grained, in beds 6 to 12 inches separated by shaly partings, bedding slightly wavy. Scattered small crinoidal remains give the rock a granular appearance. Fossiliferous.....	9	
7.	Limestone, light bluish to red, medium-grained, in thin beds with shaly partings.....	2	
6.	Limestone, light bluish gray, compact, fine-grained, beds about 6 inches thick.....	1	8
5.	Limestone, reddish, medium-grained, beds thin and somewhat nodular, shaly partings, but weathers as a single massive division, contains scattered crinoid fragments...	5	
3.	Limestone, light bluish gray with greenish cast, medium-grained, with scattered crinoid remains that give rock granular appearance, beds 4 to 15 inches thick, with shaly partings.....	17	
2.	Shale, bluish green, clayey to sandy, the sand consisting of well rounded coarse quartz grains, base uneven.....		1-6
<i>Unconformity</i>			
Ordovician			
1.	Dolomite, gray, fine-grained, cherty. Exposed.....	5	

A section measured at the village of Elk Springs, in northern McDonald county, shows the character and stratigraphic relations of the St. Joe limestone. The beds are best exposed in the Truitt quarry just south of the Kansas City Southern Railway station. The Chattanooga shale is to be seen all along the tracks south of Elk Springs but is about a foot below the floor of the quarry.

(35) Section at Truitt Quarry, South of Elk Springs, McDonald County

		Thickness	
		Feet.	Inches.
Osage group			
Boone formation			
Reeds Spring limestone member			
7.	Limestone and chert, the limestone, blue, fine-grained, very dense, in thin beds alternating with dark flinty chert. Exposed.....	15	
6.	Shale, greenish to brownish, clayey and sandy, thin beds of limestone in upper part.....	1	4
St. Joe limestone member			
5.	Limestone, light bluish, medium- to fine-grained, beds thin and nodular, separated by greenish calcareous shale partings, appears massive in fresh exposures.....	28	
4.	Limestone, greenish blue, shaly, soft, forms re-entrant in cliff, beds wavy, uneven.....	2	
3.	Limestone, light greenish blue, fine-grained but contains crinoidal fragments that give the rock a granular appearance. The basal 9 to 12 inches contains numerous rounded to angular fragments of compact blue limestone forming a conglomerate that rests on the slightly uneven surface of the next lower bed.....	5	6
<i>Local ? Disconformity</i>			
2.	Limestone, light greenish blue, medium to fine-grained, beds 4 to 8 inches thick, nodular, with wavy shale partings. Some layers slightly crinoidal.....	7	
<i>Disconformity</i>			
Kinderhook group			
Chattanooga shale			
1.	Shale, black, fissile, exposed.....	3	

Exposures are excellent along the Joplin-Noel highway (U. S. 71) for several miles north of Noel, in southern McDonald county near the Arkansas state line. A section measured about a mile north of Noel shows 34 feet of St. Joe limestone above the Chattanooga black shale and beneath the cherty Reeds Spring limestone.

(36) Section on Joplin Highway, One Mile North of Noel, McDonald County

		Thickness	
		Feet.	Inches.
Osage group			
Boone formation			
Reeds Spring limestone member			
5.	Limestone, blue, fine-grained, compact, hard, subconchoidal fracture, contains numerous thin bands of dark bluish to nearly black chert.....	80-90	
St. Joe limestone member			
4.	Limestone, light blue to white, beds slightly wavy, massive hard, forms prominent projection along cliff, chert in lenses and thin bands present locally. In some places there are distinct alternating layers of medium-grained hard limestone and soft nodular beds.....	20-24	
3.	Limestone, light bluish to greenish, shaly, grading laterally into limy shale, forms prominent re-entrant in the cliffs, sparsely fossiliferous.....	4	6
2.	Limestone, light bluish gray, fine to medium-grained, compact, thin-bedded, with wavy laminae of light greenish calcareous shale. This zone weathers in places as massive rock projecting over bed 1. Contains a few fossils.....	5	8

		Thickness
		Feet. Inches.
<i>Disconformity</i>		
Kinderhook group		
Chattanooga shale		
1. Shale, black, dull luster, fissile, carbonaceous, weathers in small flakes, outcrop commonly marked by prominent joints obliquely inclined to bedding. Contains small pyrite concretions. Exposed.....		12

One and a half miles south of Noel, on the east side of the Kansas City Southern Railroad, is an old quarry where the St. Joe limestone and the overlying cherty Reeds Spring can be studied to advantage. A section measured here is as follows:

(37) Section in Quarry 1 1-2 Miles South of Noel, McDonald County

		Thickness
		Feet. Inches.
Osage group		
Boone formation		
Reeds Spring limestone member		
3. Limestone and chert, the limestone drab blue, fine-grained dense, in thin beds alternating with nodular layers of bluish black flinty chert. Exposed.....		10
2. Shale, bluish green to yellowish brown, clayey, sandy at base.		4 to 6
St. Joe limestone member		
1. Limestone, light bluish, rather fine-grained, compact, in nodular wavy layers separated by thin laminae of greenish calcareous shale. Some beds contain scattered crinoid fragments giving rock granular appearance. Fossiliferous. Exposed.....		21

Collections of fossils secured at the places described in the foregoing sections are recorded in the faunal table for the St. Joe limestone. The list for the district southeast of Reeds Spring represents specimens from beds 6 to 8, inclusive, of the Reeds Spring section at a place two miles southeast of the town. The collection north of Noel comes from Bed 3 of the section described one mile from the town. The collection north of Ozark, in Christian county, was obtained in a light gray clayey shale at the top of dark bluish (St. Joe ?) limestone and beneath interstratified dense, dark blue limestone and dark chert which is characteristic of the Reeds Spring limestone member of the Boone in southwestern Missouri.

XXIV. Fauna of the St. Joe Limestone

Localities*	A	B	C	D	E
<i>Corals</i>					
Cyathaxonia arcuata Weller.....	x	x	?	—	—
Cyathaxonia minor Weller.....	—	x	x	—	—
Cyathaxonia n. sp.....	x	—	—	—	—
Zaphrentis cliffordana E. & H.....	—	x	—	?	x

FAUNAL TABLE XXIV—Continued.

Localities*	A	B	C	D	E
<i>Corals—Cont'd</i>					
<i>Zaphrentis wortheni</i> Weller	—	—	—	—	x
<i>Zaphrentis</i> sp.	x	2	x	x	2
<i>Amplexus brevis</i> Weller	x	x	—	—	x
<i>Amplexus blairi</i> Miller	—	—	—	x	—
<i>Amplexus rugosus</i> Weller ?	x	—	—	—	—
<i>Amplexus</i> sp.	—	—	x	x	x
<i>Palaeacis bifidus</i> Weller	—	x	—	—	—
<i>Cladochonus americanus</i> Weller	—	x	x	—	x
<i>Blastoid</i>					
<i>Schizoblastus roemeri</i> (Shumard)	—	—	x	—	—
<i>Crinoids</i>					
<i>Actinocrinus arrosus</i> Miller	—	—	x	—	—
<i>Cactocrinus</i> n. sp.	—	—	—	x	—
<i>Uperocrinus</i> sp.	x	—	—	—	—
<i>Platycrinus</i> sp.	—	x	x	—	—
<i>Cyathocrinus</i> sp.	x	—	—	x	—
Species undetermined	—	—	—	—	x
<i>Bryozoans</i>					
<i>Fistulipora fernglenensis</i> Weller	x	—	—	—	—
<i>Fenestella</i> sp.	—	2	x	x	—
<i>Chilotrypa</i> sp.	—	—	—	—	x
<i>Pinnatopora</i> sp.	—	—	—	—	x
<i>Rhombopora</i> sp.	—	2	—	—	x
<i>Cystodictya lineata</i> Ulrich	—	—	—	—	x
<i>Cystodictya</i> sp.	—	x	—	—	—
<i>Evactinopora sexradiata</i> M. & W.	x	x	—	—	x
<i>Brachiopods</i>					
<i>Leptaena analoga</i> (Phillips)	—	x	x	x	x
<i>Schuchertella fernglenensis</i> (Weller)	—	—	x	—	—
<i>Chonetes glenparkensis</i> Weller	—	—	x	—	—
<i>Chonetes illinoisensis</i> Worthen	—	x	—	—	—
<i>Chonetes logani</i> N. & P.	—	?	—	x	—
<i>Chonetes</i> sp.	—	—	x	—	—
<i>Productus fernglenensis</i> Weller	x	x	—	—	x
<i>Productus sampsoni</i> Weller	x	x	x	—	x
<i>Productus</i> sp. cf. <i>P. ovatus</i> Hall	—	—	x	—	—
<i>Productus</i> sp. cf. <i>P. arcuatus</i> Hall	—	x	—	—	—
<i>Pustula concentrica</i> (Hall)	—	—	x	—	—
<i>Rhipidomella jerseyensis</i> Weller	x	x	—	x	x
<i>Rhipidomella burlingtonensis</i> Hall	—	x	cf	—	—
<i>Rhipidomella</i> sp.	—	—	—	x	2
<i>Schizophoria subelliptica</i> W. & W.	—	x	—	—	cf
<i>Schizophoria poststriatula</i> Weller	—	x	x	—	—
<i>Camarotoechia chouteauensis</i> Weller ?	—	—	x	—	—
<i>Camarotoechia</i> sp.	x	—	—	—	—
<i>Shumardella obsolens</i> (Hall) ?	—	—	x	—	—
<i>Rhynchopora persinuata</i> (Winchell)	—	x	x	—	—
<i>Delthyris novamexicana</i> (Miller)	x	x	x	—	—

FAUNAL TABLE XXIV—Continued.

Localities*	A	B	C	D	E
<i>Brachiopods—Cont'd</i>					
<i>Spiriferina subtexta</i> White.....	x	?	x	—	—
<i>Spiriferina</i> n. sp.	—	x	—	—	—
<i>Spirifer vernonensis</i> Swallow.....	x	x	x	x	x
<i>Spirifer rowleyi</i> Weller.....	—	x	x	?	x
<i>Spirifer louisianensis</i> Rowley.....	—	—	x	x	—
<i>Spirifer imbrex</i> Hall.....	—	—	—	—	x
<i>Spirifer shepardii</i> Weller.....	—	—	—	x	x
<i>Spirifer striatiformis</i> Meek ?.....	—	—	x	—	—
<i>Spirifer missouriensis</i> Swallow ?.....	—	—	x	—	—
<i>Spirifer</i> sp.....	—	x	2	—	—
<i>Brachythyris chouteauensis</i> Weller.....	—	—	x	—	x
<i>Brachythyris suborbicularis</i> (Hall) ?.....	—	—	—	x	—
<i>Syringothyris</i> sp.....	—	—	—	—	x
<i>Pseudosyrinx sampsoni</i> Weller.....	—	x	—	—	—
<i>Reticularia cooperensis</i> (Swallow).....	—	—	—	x	—
<i>Athyris lamellosa</i> (L'Eveille).....	x	x	x	—	x
<i>Cliothyridina tenuilineata</i> (Rowley).....	x	x	cf	—	—
<i>Cliothyridina prouti</i> (Swallow).....	—	x	x	—	x
<i>Cliothyridina glenparkensis</i> Weller.....	—	x	—	—	x
<i>Cliothyridina obmaxima</i> (McChesney) ?.....	—	—	—	—	x
<i>Cliothyridina</i> sp.....	—	—	x	—	—
<i>Gastropods</i>					
<i>Holopea</i> sp.....	—	x	—	—	—
<i>Platyceras paralum</i> W. & W.....	—	x	—	x	x
<i>Platyceras</i> sp. 1, 2.....	—	—	x	—	—
<i>Orthonychia</i> sp.....	—	—	—	x	—
<i>Trilobites</i>					
<i>Phillipsia sampsoni</i> Vogdes.....	—	x	—	—	—
<i>Proetus</i> sp. cf. <i>P. fernglenensis</i> Weller.....	—	—	—	—	x
<i>Fish</i>					
Fish tooth.....	—	—	x	—	—

*A. Shale just below Reeds Spring limestone north of Ozark, Christian County.

B. Two miles southeast of Reeds Spring, Stone County; beds 6-8 of section.

C. Truitt quarry south of Elk Springs, McDonald County.

D. One mile south of Noel, McDonald County; bed 3 of section.

E. One and a half miles south of Noel; bed 1 of section.

CORRELATION OF EARLY OSAGE BEDS

In peculiarities of lithologic character, bedding and appearance in the field, the St. Joe limestone strikingly resembles the Fern Glen formation. Both the St. Joe and Fern Glen rest unconformably on patches of Kinderhook strata or on older rocks ranging in age to Ordovician, and the faunas show a marked resemblance not only in general composition but in the

presence of many distinctive species. Among the characteristic Fern Glen species are *Cyathaxonia arcuata*, *Evactinopora sex-radiata*, *Productus sampsoni*, *P. fernglenensis*, *Rhipidomella jerseyensis*, *Rhynchopora persinuata*, *Delthyris novamexicana*, *Spirifer vernonensis*, *S. rowleyi*, *S. shepardi*, *Brachythyris chouteauensis*, *Cliothyridina glenparkensis*, *C. prouti* and *Schuchertella fernglenensis*. There are some species from the older Kinderhook and an element which persists into the succeeding Osage limestone, but the horizon is well marked by forms that do not range above or below this position. There can be no question as to the essential equivalence of these formations. However, there are grounds for the suggestion that the St. Joe limestone does not include beds corresponding to the upper chert-bearing part of the Fern Glen, and that the dark blue, fine-grained, very cherty Reeds Spring limestone may correspond to this younger portion of the Fern Glen deposits. Faunal Table XLI, presents a comparison of the faunas of the early Osage formations here described and of the Lower and Upper Burlington.

The Sedalia limestone, marked chiefly by its fine-grained texture, yellowish to buff color, siliceous and magnesian composition and general soft character, corresponds to the Fern Glen and St. Joe limestone in stratigraphic position and in more or less well defined unconformable relations to the underlying rocks. In the district north of St. Louis, in Jersey county, Illinois, there is evidence of lateral change from strata of Fern Glen aspect to beds of Sedalia appearance. The coralline and brachiopod fauna of the Sedalia finds corresponding elements in the Fern Glen-St. Joe formations, and many of the species which are regarded as diagnostic of the greenish and reddish, more or less shaly beds of these formations, are also found in the Sedalia. It is interesting to note the possible significance of the occurrence in the Fern Glen, Sedalia and Reeds Spring of a peculiar variety of chert, which is unlike the chert found in most of the Burlington limestone. All of the evidence at hand supports the conclusion that the Sedalia is at least in part the time equivalent of the Fern Glen and St. Joe deposits.*

*Frank Springer, whose authoritative knowledge of the Mississippian crinoids gives weight to conclusions advanced by him as a result of study of these excellent stratigraphic markers, notes (The Crinoidea Flexibilia, Smithsonian Publ. 2501, p. 196, 1920): "The upper part of what in Missouri is called the 'Chouteau' is the same thing as the Lower Burlington beds in Iowa." He has reference to the zone of *Cactocrinus proboscivalis*, which comprises the Lake Valley beds, New Mexico, the Sedalia limestone, a portion of the Lower Burlington, and the LeGrand crinoid beds of central Iowa.

The Pierson limestone has been less studied by the writer than the other formations discussed. Its stratigraphic position, lithologic character and faunal aspect ally it with the beds that are here distinguished as early Osage. Detailed work in the region from central to southwestern Missouri will undoubtedly reveal relationships between Sedalia, Pierson and St. Joe which are not now known. In the light of present stratigraphic evidence it seems best to employ the local formation names and to indicate the correlation between them.

Approximately contemporaneous deposits belonging in the early part of the Osage epoch are widespread. In the Lake Valley region of New Mexico, far to the southwest, a fauna has been recorded which is closely comparable with that of the Fern Glen,⁶⁹ and it appears that the early Osage is well represented elsewhere in the Rocky Mountain region in a part of the Madison limestone. In Indiana, Kentucky and Tennessee, the New Providence formation contains abundant faunal evidence showing that it is Fern Glen and possibly Lower Burlington in age.¹⁰ In Ohio the Cuyahoga and Logan formations have a like fauna and may be traced into the New Providence. The sea of this time extended southeastward far into Alabama for the lower part of the Fort Payne chert in many places yields a fauna like that of the New Providence or Fern Glen. Butts¹⁰ has shown that the Cuyahoga and Logan formations are equivalent to most of the widespread Pocono formation of Pennsylvania, Maryland, West Virginia and eastern Tennessee. This deposit, partly terrestrial in origin, is of Fern Glen and possibly in part Lower Burlington age. It is separated from succeeding beds by a stratigraphic break that in most places represents all of later Osage and most of Meramec time, and commonly the next younger deposit is middle or later Chester. In all of this region east of the Mississippi there appear to be no beds of Upper Burlington age, the early Osage being thus sharply set off from the younger rocks.

BURLINGTON LIMESTONE .

The Burlington limestone was named by James Hall¹⁷ in 1857 to include the beds which Owen³⁶ had called the "Encrinital group of Burlington" and the "reddish brown Encrinital group of Hannibal." The name Burlington displaced "Encrinital limestone" which had been used by Swallow⁵¹ and Shumard⁴⁴ on the first Missouri Geological Survey. In the first report of the

Geological Survey of Iowa, Hall¹⁸ states that the Burlington "succeeds the sandstones and beds of limestone of the Chemung (Kinderhook) and underlies the Keokuk limestone at the base of which lies a succession of cherty beds that produce the rapids just above the town of Keokuk. It is subcrystalline in texture, gray or brown and in some parts nearly white in color, often quite friable, and largely constituted of the remains of crinoideae." As thus defined the formation has remained practically without change in the reports of later geologists.

General character. As observed in most exposures the Burlington limestone is an unusually coarse-grained, crystalline, crinoidal limestone. Its texture is sufficiently distinctive and persistent to permit recognition of the formation commonly on this basis alone. In color the limestone varies from light gray or almost white to yellowish buff or rather deep brown. The gray and white portions of the formation are the purest, those of darker color containing impurities, consisting chiefly of iron. The Burlington limestone is made almost entirely of the remains of various fossils, by far the most important of which are crinoids. Some portions of the Burlington, however, are not so evidently crinoidal, as for example the so-called "White ledge" which is extensively quarried in the northeastern part of Missouri. The beds of the Burlington are mostly several feet thick suggesting uniformity of conditions during deposition. However parts of the formation consist of thin, uneven, cherty beds.

The nearly pure character of much of the Burlington limestone is shown by numerous published analyses⁹ reporting more than 99 per cent calcium carbonate. Parts of the formation contain an appreciable amount of magnesium carbonate, in some beds large enough to permit designation as a dolomite. These magnesian or dolomitic portions appear as layers interbedded with almost pure limestone, or as irregular, ill-defined parts which may grade laterally into pure limestone. The magnesian layers are yellowish, buff, or brown in color, due possibly to greater iron content. In some of the magnesian beds there are fossil fragments of crystalline calcite, not replaced, but in others the fossils have been almost entirely obliterated.

The Burlington limestone is a cherty formation. The chert occurs in irregular nodules varying in size from small bodies not larger than an egg to massive lenticular masses eighteen inches in thickness and three or four feet in horizontal dimensions. The nodules are in most cases arranged in bands at varying

intervals through the formation, but they may be scattered somewhat irregularly through the beds. Commonly also the chert forms continuous bands or sheets of variable thickness and regularity. There is a certain observable difference in the texture of the chert in different parts of the Burlington, similar to that which differentiates the cherts of the Burlington from those of other formations. In the residual Mississippian cherts which have been found well toward the center of the Ozark dome there is a difference in texture corresponding to the difference in age as indicated by the contained fossils.

The Burlington is generally marked by numerous "suture joints" or stylolites which range from barely perceptible irregular lines to prominent joints with projections more than six inches in length, the rock on one side interlocking with that on the other. The stylolites consist of fluted, slickensided columns of limestone variable in length and diameter. At the end of each column there is a thin cap of clayey or bituminous matter.

The Reeds Spring limestone member of the Boone formation of Lower Burlington and possibly in part of Fern Glen age, consists of nearly equal parts of very dense, hard, fine-grained blue limestone and very dark chert. The limestone and chert commonly occur in rather even, thin, regularly alternating layers. The appearance of some exposures suggests a horizontally banded wall. In the lower part of the formation the chert is somewhat less abundant and the limestone beds are more massive. The contact with the St. Joe limestone is drawn at the lowest chert horizon. Parts of the limestone contain crinoid and other fossil fragments which give the rock a speckled appearance, but in general there are few well preserved fossils. The chert is uniformly dark blue to nearly black, and flinty. Almost without exception the chert bands or nodules are bordered by a zone $\frac{1}{8}$ to $\frac{1}{2}$ inch in thickness consisting of fine granular light colored chert; the contact with the dark flinty chert is sharp. Many of the nodules surround irregular masses of more or less siliceous limestone resembling the associated limestone matrix. Solution of the limestone gives the chert a very rough, irregularly cavernous surface. The chert nodules vary in shape from small subspherical bodies to flattened pancake-like lenses or very irregular forms. Some of the chert beds show even upper and lower surfaces but contain irregular inclusions of limestone.

Distribution and thickness. The Burlington limestone is found over a considerable portion of southeastern Iowa in the

vicinity of its type locality at Burlington and on the east side of Mississippi river it crops out at intervals from a point northeast of Burlington to extreme southern Illinois. In Missouri the Burlington appears at the surface in Lewis and Knox counties, northeastern Missouri, covers the larger portion of Shelby and Marion counties and is exposed at numerous places in Monroe, Ralls, Pike, Lincoln and St. Charles counties. On the south side of Missouri river the formation is found in the vicinity of St. Louis and southward into Jefferson, Ste. Genevieve and Perry counties. North of Missouri river the Burlington forms an almost continuous south-facing escarpment. The outcrop of the Burlington in Warren, Montgomery, Callaway and Boone counties is irregular, and there are numerous outliers. The formation makes high bluffs along both sides of the Missouri a short distance west of Jefferson City, extending up-stream to a point in western Howard county two or three miles south of Glasgow. It is the surface rock over a large portion of Cooper and Pettis counties and is well exposed in several quarries and along streams. Farther south the area of Mississippian outcrop shrinks to a narrow irregular strip but the Burlington is typically developed. It forms high bluffs along Osage river in Benton and St. Clair counties and is exposed on many streams in the southwestern part of the state. In Dade and Greene counties, especially in the vicinity of Springfield and Ash Grove, there are good exposures of the Burlington showing lithologic characters essentially similar to those of southeastern Iowa. To the south of Springfield and Joplin the coarse-grained crinoidal limestones are mostly found to contain Keokuk or younger fossils, but the early Osage is represented by the dark, dense, cherty Reeds Spring limestone. This member of the Boone is well exposed along many streams in the southwest corner of the state.

The average thickness of the Burlington limestone is about 100 feet in northeastern Missouri but it is 150 feet or more in the central part of the state. The Lower division of the Burlington commonly exceeds the Upper in thickness. In southwestern Missouri the Reeds Spring limestone ranges in thickness from about 130 feet east of Oronogo and near Porto Rico to 225 feet near Wentworth. The average of some scores of records in the Joplin district is around 150 feet.

Stratigraphic sections and faunal lists. The character of the Burlington limestone and the fossils observed in various sections examined by the writer are recorded in the following pages:

(38) Section of Burlington Limestone at Lovers Leap, South of Hannibal

Osage group		Thickness	
Burlington limestone		Feet.	Inches.
(Upper Burlington)			
17.	Limestone, light gray, weathering brownish, coarsely crystalline, fossiliferous, containing especially <i>Spirifer grimesi</i> Hall.	3	6
16.	Limestone, grayish brown, medium to coarse-grained, crystalline, thinly interbedded with chert.	10	
15.	Limestone, rich brown, ferruginous, fine-grained, massive, contains scattered calcite-filled geodes, fish teeth present.	2	6
14.	Limestone, light gray to grayish brown, coarse-grained, crystalline, very massive, forms overhanging ledge, fossiliferous, containing large numbers of <i>Spirifer grimesi</i> Hall.	5	
13.	Limestone, brown, coarse-grained, somewhat magnesian, single massive ledge, laterally becomes cherty and includes bands of fine-grained rock.	4	
12.	Limestone, brown, fine-grained, magnesian, cherty.	2	6
11.	Limestone, gray to light buff, coarsely crystalline, massive, contains a few very thin chert beds.	8	
10.	Limestone, brownish, fine-grained, somewhat magnesian, massive, contains thick chert bands.	8	
9.	Limestone, light brown, fine-grained, massive, non-cherty but contains small calcite-filled geodes.	5	
8.	Limestone, light brown, magnesian, fine-grained, unevenly bedded, with numerous chert bands.	7	6
(Lower Burlington)			
7.	Limestone, buff, crystalline, in beds about 2 feet thick, contains nodular chert up to 1½ feet in thickness.	4	
6.	Limestone, brown, massive, coarsely crystalline, showing abundant crinoid fragments, a thin band of nodular chert near the middle.	5	6
5.	Limestone, brown, magnesian, fine-grained, with large irregularly disposed chert nodules.	5	
4.	Covered.	15	
3.	Limestone, light gray to white, very massive, pure, coarse crystalline, a single bed.	12	
2.	Limestone, light buff to brown, massive, medium to coarse grained, cherty, the chert occurring in large nodules at horizons about 3 feet apart.	10	
1.	Limestone, gray to light buff, very massive, coarse crystalline, crinoidal; contains irregular bands of fine-grained limestone. Stylolites common to within a few inches of base.	11	
<i>Disconformity</i>			
Kinderhook group			
Hannibal formation			
Soft bluish sandstone (See section 4 for Kinderhook portion of section).			

There is some uncertainty as to the exact division between Lower and Upper Burlington in this section, for the beds are in part similar in lithology and the cliff exposure and relative inaccessibility of fossils in most of the horizons afford difficulty. Further, the beds below the covered zone (4) were measured at one place and those above at another. The top of the Lower Burlington is tentatively placed at Bed 7; the thickness thus indicated, 62½ feet, accords with other observations in this region. Strata assigned to the Upper Burlington in this section

measure 56 feet, but the base of the Keokuk was not seen here. Plate III showing Lovers Leap indicates clearly the general difference in the appearance of the Lower and Upper Burlington.

XXV. Fossils From the Burlington Limestone at Lovers Leap, Hannibal

Bed's	11	14
<i>Coral</i>		
<i>Triplophyllum dalei</i> (E. & H.)	x	—
<i>Bryozoans</i>		
<i>Fenestella</i> sp.	x	x
<i>Glyptopora</i> sp.	x	—
<i>Brachiopods</i>		
<i>Schellwienella</i> sp.	—	x
<i>Chonetes illinoisensis</i> Worthen	x	x
<i>Productus viminalis</i> White	x	x
<i>Productus burlingtonensis</i> Hall ?	—	x
<i>Pustula alternata</i> (N. & P.)	?	cf
<i>Rhipidomella burlingtonensis</i> Hall	x	x
<i>Rhipidomella dubia</i> Hall	cf	?
<i>Rhipidomella</i> sp.	—	x
<i>Schizophoria swallovi</i> (Hall)	—	x
<i>Camarotoechia</i> sp.	x	—
<i>Cranaena globosa</i> Weller	x	—
<i>Spirifer incertus</i> Hall	?	—
<i>Spirifer grimesi</i> Hall	x	x
<i>Spirifer</i> sp.	—	x
<i>Brachythyris</i> sp.	x	—
<i>Pseudosyrinx missouriensis</i> Weller	x	—
<i>Pseudosyrinx</i> ? sp.	x	—
<i>Athyris lamellosa</i> (L'Eveille)	x	x
<i>Cliothyridina incrassata</i> (Hall)	—	x
<i>Gastropods</i>		
<i>Platyceras latum</i> (Keyes) ?	—	x
<i>Platyceras</i> sp.	x	—

(39.) Section of the Burlington Limestone at the Hannibal Lime Quarry, Hannibal

Osage group	Thickness Feet. Inches.
Burlington limestone	
(Upper Burlington)	
7. Limestone, dark brown, magnesian, ferruginous, crinoidal, massive, very cherty	3
(Lower Burlington)	
6. Limestone, light brown to bluish gray, partially dolo- matized, medium-grained, chert abundant	30
5. Limestone, light gray to white, pure, medium to coarse- grained, massive, hard, crystalline, fossiliferous, <i>Spirifer</i> <i>forbesi</i> N. and P. abundant	12 6

	Thickness	
	Feet.	Inches.
4. Limestone, brown to light gray, partly magnesian, medium to coarse-grained.....	1	3
3. Limestone, light gray to brownish, pure, massive, coarse-grained.....	5	
2. Limestone, brown, magnesian, medium- to fine-grained, partly crinoidal, massive, contains large chert nodules irregularly distributed through bed.....	5	
1. Limestone, light brownish gray, medium to coarse-grained, crystalline, crinoidal (exposed). Covered.....	3	
Total.....	60	

XXVI. Fauna of the Burlington Limestone at Hannibal Lime Company Quarry,
Hannibal, Missouri

Beds	1	3	4	5	6	7
<i>Corals</i>						
<i>Zaphrentis</i> sp.....	x	x	-	x	x	-
<i>Triplophyllum dalei</i> (E. & H).....	-	-	-	-	-	x
<i>Monilopora</i> sp.....	-	x	-	-	-	-
<i>Blastoids</i>						
<i>Cryptoblastus melo</i> (O. & S.).....	-	-	x	-	-	-
<i>Orbitremites norwoodi</i> (O. & S.).....	x	-	?	-	-	x
<i>Crinoids</i>						
<i>Gilbertsocrinus</i> sp.....	-	-	-	-	-	x
<i>Batocrinus clypeatus</i> (Hall).....	-	-	-	-	-	x
<i>Batocrinus</i> sp.....	-	-	x	-	-	-
<i>Eretmocrinus clio</i> (Hall).....	-	-	-	-	-	x
<i>Macrocrinus verneuillianus</i> (Shumard).....	-	-	-	-	-	x
<i>Dizygocrinus andrewsianus</i> (McChesney)....	-	-	-	-	-	x
<i>Eutrochocrinus christyi</i> (Shumard).....	-	-	-	-	-	x
<i>Eutrochocrinus lovei</i> (W. & S.).....	-	-	-	-	-	x
<i>Uperocrinus pyriformis</i> (Shumard).....	-	-	-	-	-	x
<i>Uperocrinus hageri</i> (McChesney).....	-	-	-	-	-	x
<i>Uperocrinus aequibrachiatus asteriscus</i> (M. & W.).....	-	-	-	-	-	x
<i>Aorocrinus parvus</i> (Shumard).....	-	-	-	-	-	x
<i>Dorycrinus missouriensis</i> (Shumard).....	-	-	-	-	-	x
<i>Dorycrinus</i> ? sp.....	-	-	-	-	-	x
<i>Agaricocrinus fiscellus</i> (Hall).....	-	-	-	-	-	x
<i>Agaricocrinus planoconvexus</i> (Hall).....	-	-	-	-	-	x
<i>Actinocrinus scitulus</i> M. & W. ?.....	-	-	-	-	-	x
<i>Actinocrinus verrucosus</i> Hall.....	-	-	-	-	-	x
<i>Cactocrinus obesus</i> (Keyes) ?.....	-	-	-	-	-	x
<i>Strotocrinus regalis</i> (Hall).....	-	-	-	-	-	x
<i>Platycrinus planus</i> Hall ?.....	-	-	-	-	-	x
<i>Platycrinus cavus</i> Hall.....	-	-	-	-	-	x
<i>Platycrinus</i> sp. 1, 2, 3, 4.....	-	-	-	-	-	x
<i>Eucladocrinus pleurovimeus</i> (White).....	-	-	-	-	-	x
<i>Barycrinus sculptilis</i> (Hall).....	-	-	-	-	-	x

FAUNAL TABLE XXVI—Continued.

Beds	1	3	4	5	6	7
<i>Bryozoans</i>						
Fenestella sp. 1, 2, 3, 4.....	—	x	—	x	—	—
Ptilopora sp.....	—	x	—	—	—	—
Glyptopora sp.....	—	x	—	—	—	—
<i>Brachiopods</i>						
Leptaena analoga (Phillips).....	—	—	—	x	x	—
Schellwienella alternata Weller ?.....	—	x	—	x	—	—
Schellwienella n. sp.....	—	—	—	x	—	—
Schellwienella sp.....	—	x	?	—	x	—
Chonetes illinoisensis Worthen.....	—	x	—	x	—	—
Chonetes glenparkensis Weller.....	—	x	cf	x	cf	—
Chonetes multicostus Winchell.....	—	x	—	—	—	—
Productus burlingtonensis Hall.....	—	x	x	x	x	x
Productus sampsoni Weller.....	—	x	x	x	x	—
Productus viminalis White.....	—	x	—	—	—	—
Productus sp.....	x	x	—	—	—	—
Productus sp.....	—	—	x	—	—	—
Productus sp.....	—	—	x	—	—	—
Pustula laevicula Moore.....	x	x	—	—	—	—
Pustula morbilliana (Winchell) ?.....	—	x	—	—	—	—
Pustula concentrica (Hall) ?.....	—	x	—	—	—	—
Pustula sp.....	—	—	—	x	—	—
Rhipidomella thiemei White ?.....	x	—	x	—	—	—
Rhipidomella burlingtonensis (Hall).....	—	—	—	x	x	x
Rhipidomella diminutiva (Rowley).....	—	x	—	x	—	—
Rhipidomella sp.....	—	—	—	x	—	—
Schizophoria swallowi (Hall).....	x	—	x	x	—	—
Schizophoria chouteauensis Weller ?.....	—	x	—	—	—	—
Rhynchotetra missouriensis Weller.....	—	—	—	x	—	—
Rhynchopora ? cooperensis (Shumard) ?.....	—	—	—	x	—	—
Centronelloidea rowleyi (Worthen).....	—	—	—	x	—	—
Dielasma chouteauense Weller.....	—	—	—	x	—	—
Spiriferina subtexta White.....	—	x	—	—	—	—
Spirifer grimesi Hall.....	x	—	—	x	x	x
Spirifer forbesi N. & P.....	—	x	x	x	x	—
Spirifer louisianensis Rowley.....	?	x	—	x	—	—
Spirifer mundulus Rowley.....	—	?	—	x	—	—
Spirifer sp.....	—	x	—	—	—	—
Spirifer sp.....	—	—	—	x	—	—
Brachythyris suborbicularis (Hall).....	x	—	—	—	x	—
Brachythyris chouteauensis (Weller).....	—	x	—	x	—	—
Syringothyris sp. cf. S. typus Winchell.....	—	—	—	x	—	—
Syringothyris sp.....	—	—	—	x	?	—
Pseudosyrinx missouriensis Weller.....	?	—	—	x	—	—
Reticularia sp.....	—	x	—	—	—	—
Rowleyella fabulites (Rowley) ?.....	—	x	—	—	—	—
Athyris lamellosa (L'Eveille).....	x	—	—	x	x	x
Cliothyridina tenuilineata (Rowley).....	—	x	x	—	—	—
Cliothyridina incrassata (Hall).....	—	—	—	x	—	—

FAUNAL TABLE XXVI—Continued.

Beds	1	3	4	5	6	7
<i>Pelecypods</i>						
Cardiopsis sp.	—	x	—	—	—	—
Aviculopecten sp. 1, 2.	—	x	—	—	—	—
<i>Gastropods</i>						
Platyceras paralum W. & W.	—	x	—	—	—	x
Platyceras obliquum Keyes.	—	—	—	x	—	—
Platyceras sp. 1, 2, 3.	—	x	—	—	—	—
Platyceras sp.	—	—	x	—	—	—
Orthonychia sp. 1, 2.	—	x	—	—	—	—
Igoceras pabulocrinum (Owen).	—	?	cf	—	—	—
Igoceras capulum (Hall).	—	x	—	x	—	—
<i>Trilobite</i>						
Phillipsia insignis Winchell ?	—	—	—	x	—	—

(40.) Section of the Burlington Limestone at Huston Quarry, Hannibal, Missouri

Loess	Thickness Feet. Inches.	
Osage group		
Burlington limestone (Lower)		
10. Limestone, brown, ferruginous, magnesian, thin-bedded, cherty.	3	
9. Limestone, light bluish gray, coarsely crystalline, crinoidal, very hard, thin-bedded, siliceous.	13	
8. Limestone, brown, magnesian, massive, contains chert nodules.	6	
7. Limestone, light gray, coarse crystalline, crinoidal, massive, fossiliferous.	3	
6. Limestone, dark brown, magnesian, ferruginous, massive, unfossiliferous.	3	
5. Limestone, bluish gray, medium to coarse crystalline, crinoidal, few fossils, cherty in places.	8	
4. Limestone, brown, magnesian, medium-grained, massive, crinoidal in part.	5	6
3. Limestone, light buff, mottled, to brown, granular, crinoid fragments, massive (exposed).	6	
2. Covered.	18	
1. Limestone, gray, crystalline, medium-grained, massive.	1	
Total.	66	
<i>Disconformity</i>		
Kinderhook group		
Hannibal shale		

XXVII. Fauna of the Burlington Limestone in the Huston Lime Quarry, Hannibal

Beds	3	5	7	8	9
<i>Corals</i>					
Zaphrentis cliffordana (E. & H.).	—	—	x	—	—
Zaphrentis sp.	—	x	—	x	x
Triplophyllum dalei (E. & H.).	—	—	x	—	—
Amplexus sp.	—	—	—	x	—

FAUNAL TABLE XXVII—Continued.

Beds	3	5	7	8	9
<i>Crinoid</i>					
Platycrinus sp.	—	—	x	—	—
<i>Bryozoans</i>					
Fenestella sp.	x	—	x	—	—
Hemitrypa sp.	—	—	x	—	—
Glyptopora sp.	x	—	x	—	—
Meekopora ? sp.	x	—	x	—	—
<i>Brachiopods</i>					
Leptaena analoga (Phillips)	—	—	x	x	x
Leptaena convexa Weller ?	—	—	x	—	—
Schellwienella sp.	x	?	x	?	—
Chonetes illinoisensis Worthen	—	—	x	x	—
Productus burlingtonensis Hall	x	—	x	—	—
Productus sampsoni Weller	—	—	x	x	—
Productus ovatus Hall	—	—	x	—	—
Productus viminalis White	—	—	—	x	—
Productus sp.	x	—	x	—	—
Pustula concentrica (Hall) ?	x	—	—	—	—
Pustula levicula Moore ?	—	—	x	—	—
Pustula morbilliana (Winchell)	—	—	x	—	—
Pustula sp.	—	—	x	—	—
Rhipidomella burlingtonensis (Hall)	x	—	?	x	x
Rhipidomella thiemei White ?	—	—	x	—	—
Rhipidomella diminutiva (Rowley)	—	—	—	—	x
Schizophoria swallowi (Hall)	?	x	x	—	x
Camarotoechia elegantula Rowley	—	—	x	—	—
Camarotoechia sp.	x	—	—	—	x
Pugnoides boonensis (Shumard)	?	—	x	—	—
Rhynchopora ? sp.	—	x	—	—	—
Rhynchopora ? sp.	x	—	—	—	x
Dielasma burlingtonense (White) ?	—	—	x	—	—
Dielasma sp.	—	—	—	x	—
Spiriferina subtexta White	—	—	x	x	?
Spirifer forbesi N. & P.	x	x	x	?	cf
Spirifer grimesi Hall	x	x	x	x	x
Spirifer louisianensis Rowley	—	—	x	—	?
Spirifer incertus Hall	—	—	x	—	—
Spirifer sp.	—	—	x	—	—
Brachythyris suborbicularis (Hall) ?	x	—	—	—	—
Syringothyris sp.	—	—	x	—	?
Pseudosyrinx missouriensis Weller ?	—	—	x	—	—
Spiriferella ? sp.	x	—	—	—	x
Reticularia pseudolineata (Hall)	—	—	x	—	—
Reticularia sp.	—	—	—	x	—
Athyris lamellosa (L'Eveille)	x	—	x	?	—
<i>Gastropods</i>					
Platyceras paraliun W. & W.	—	—	—	x	—
Platyceras sp.	x	—	x	—	—

FAUNAL TABLE XXVII—Continued.

Beds	3	5	7	8	9
<i>Gastropods—Cont'd</i>					
Iloceras capulum Keyes.....	x	—	—	—	—
Iloceras sp.....	—	—	—	x	—
Orthonychia sp.....	x	—	—	—	—
<i>Fish</i>					
Fish tooth.....	x	—	—	—	—

From the basal 20 feet of the Burlington limestone (Lower) on Noix creek, near Bowling Green, described in section 7, page 73, the following collections were secured:

XXVIII. Fossils From the Burlington Limestone on Noix Creek, Near Bowling Green

Beds	6	7
<i>Corals</i>		
Zaphrentis cliffordana E. & H.....	x	—
Zaphrentis sp.....	x	—
Amplexus blairi Miller ?.....	—	x
<i>Blastoids</i>		
Cryptoblastus melo (O. & S.).....	—	x
Orophocrinus stelliformis (O. & S.).....	—	x
<i>Crinoid</i>		
Rhodocrinus whitei Hall.....	—	x
<i>Bryozoans</i>		
Fenestella sp. 1, 2.....	x	—
Fenestella sp. 3.....	x	x
Lyopora sp.....	x	—
Cystodictya sp.....	x	—
<i>Brachiopods</i>		
Leptaena analoga (Phillips).....	x	—
Schellwienella burlingtonensis Weller ?.....	x	—
Schellwienella sp. cf. S. chouteauensis Weller.....	x	—
Schellwienella sp.....	x	x
Chonetes glenparkensis Weller.....	x	x
Chonetes illinoisensis Worthen.....	x	x
Productus sampsoni Weller.....	x	x
Productus ovatus Hall.....	x	—
Productus sp.....	x	x
Pustula sp.....	x	x
Rhipidomella burlingtonensis (Hall).....	?	cf
Rhipidomella diminutiva (Rowley).....	x	—
Rhipidomella sp.....	x	—
Schizophoria chouteauensis Weller ?.....	x	—

FAUNAL TABLE XXVIII—Continued.

Beds	6	7
<i>Brachiopods—Cont'd</i>		
Camarophoria bisinuata Rowley.....	x	—
Rhynchotetra gibbosa (Greger).....	x	—
Rhynchopora ? cooperensis (Shumard).....	—	x
Cranaena globosa Weller.....	x	—
Dielasma fernglenense Weller.....	x	—
Spirifer forbesi N. & P.....	x	x
Spirifer grimesi Hall.....	—	x
Spirifer louisianensis Rowley.....	x	x
Brachythyris sp.....	x	—
Syringothyris ? sp.....	x	—
Pseudosyrinx missouriensis Weller ?.....	—	x
Cliothyridina incrassata (Hall).....	—	x
Cliothyridina tenuilineata (Rowley).....	—	x
<i>Gastropods</i>		
Straparollus latus Hall.....	x	—
Platyceras paraliu W. & W.....	x	—
Platyceras sp.....	x	x
<i>Trilobite</i>		
Phillipsia ? sp.....	x	—

From the lowermost 18 feet of the Burlington limestone (Lower) exposed on Little Fabius river near Newark, Knox county, described in stratigraphic section 8, page 73, the following collection of fossils was made.

XXIX. Fauna of the Basal Portion of the Burlington Limestone on the Little Fabius River Near Newark, Knox County

<i>Corals</i>	Rhynchopora sp.
Zaphrentis elliptica White	Spirifer grimesi Hall
Zaphrentis sp.	Spirifer louisianensis Rowley ?
Triplophyllum dalei (E. & H.)	Spirifer imbrex Hall
Amplexus fragilis W. & St. J.	Spirifer rowleyi Weller ?
<i>Bryozoan</i>	Spirifer platynotus Weller ?
Fenestella sp.	Brachythyris chouteauensis Weller
<i>Brachiopods</i>	Brachythyris suborbicularis (Hall) ?
Schuchertella ? sp.	Syringothyris newarkensis Weller
Chonetes glenparkensis Weller	Athyris lamellosa (L'Eveille)
Chonetes illinoisensis Worthen	Cliothyridina tenuilineata (Rowley)
Productus vimalis White	Cliothyridina obmaxima (McChesney)
Productus burlingtonensis Hall	Cliothyridina incrassata (Hall) ?
Productus arcuatus Hall ?	<i>Gastropods</i>
Pustula alternata (N. & P.)	Platyceras nasutum Miller
Rhipidomella burlingtonensis Hall	Igoceras capulum (Keyes)
Schizophoria swallowi (Hall)	

(41) Section on Cuivre River at Frenchman Bluff, 6 Miles Northeast of Troy, Lincoln County

	Thickness	
	Feet.	Inches.
Osage group		
Burlington limestone (Lower)		
10. Limestone, bluish gray, coarse-grained, crystalline, crinoidal.	8	
9. Limestone, light bluish to brownish gray, pure, crystalline, medium to coarse-grained, massive, fossiliferous.	10	
8. Limestone, light gray to white, pure, coarse-grained, crinoidal, massive, fossiliferous.	14	
Sedalia limestone		
7. Limestone, buff, fine-grained, very massive, weathers in rounded surfaces.	11	
Disconformity ?		
Kinderhook group		
Chouteau limestone		
6. Limestone, bluish drab, hard, dense, compact, thin-bedded, locally somewhat shaly, unfossiliferous.	12	
5. Limestone, gray to bluish drab, argillaceous, subcrystalline, rather thickly bedded.	2	2
4. Limestone, yellowish with some gray bands, sandy, chert nodules in irregular bands.	2	6
3. Limestone, light greenish gray, very impure, earthy, fine-grained, weathers in rounded surface.	1	3
2. Limestone, blue to bluish drab, fine-grained, hard, compact, shaly to thin-bedded, contains calcite geodes and chert in bands and nodules, no observed fossils.	35	
1. Concealed to level of river.	51	

XXX. Fauna from Burlington Limestone at Frenchman Bluff, Lincoln County

Beds	8	9
<i>Coral</i>		
Zaphrentis sp.	x	x
<i>Brachiopods</i>		
Schellwienella sp.	x	—
Chonetes glenparkensis Weller.	x	—
Chonetes illinoisensis Worthen.	x	x
Chonetes missouriensis Weller.	x	—
Productus sp. cf. P. fernglenensis Weller.	x	—
Productus sp. cf. P. sampsoni Weller.	—	x
Productus burlingtonensis Hall.	—	x
Productus ovatus Hall.	—	x
Pustula sp. cf. P. levicula Moore.	x	—
Pustula sp.	—	x
Rhipidomella burlingtonensis (Hall) ?	x	—
Rhipidomella sp. cf. R. jerseyensis Weller.	x	—
Schizophoria sp.	x	—
Dielasma sp.	—	x
Spirifer forbesi N. & P.	x	?
Spirifer grimesi Hall.	x	x
Spirifer louisianensis Rowley.	x	x
Spirifer shepardii Weller ?	x	—
Spirifer vantuyli Moore.	—	x
Spirifer sp.	x	—

FAUNAL TABLE XXX—Continued.

Beds	8	9
<i>Brachiopods—Cont'd</i>		
Brachythyris chouteauensis Weller ?	x	x
Pseudosyrinx missouriensis Weller ?	—	x
Athyris lamellosa (L'Eveille)	x	x
<i>Gastropod</i>		
Straparollus latus Hall	x	—

The lower part of the Burlington southwest of Montgomery City in Montgomery county, described in stratigraphic section 18, contains the following species:

XXXI. Fauna of Burlington Limestone at Grenen Quarry, Montgomery, Mo. NW. 1-4, Sec. 2, T. 48 N., R. 6 W.

Beds	4	5
<i>Coral</i>		
Zaphrentis sp.	—	x
<i>Blastoid</i>		
Cryptoblastus melo (O. & S)	—	x
<i>Crinoids</i>		
Actinocrinus sp.	x	—
Batocrinus sp.	x	—
Dizygocrinus ? sp.	x	—
<i>Echinoid</i>		
Archeocidaris sp.	x	—
<i>Bryozoans</i>		
Fenestella sp.	x	x
Hemitrypa sp.	x	x
Cystodictya americana Ulrich ?	x	—
<i>Brachiopods</i>		
Leptaena analoga (Phillips)	x	—
Schellwienella sp.	x	?
Streptorhynchus tenuicostatum Weller	x	?
Chonetes illinoisensis Worthen	x	x
Chonetes logani N. & P. ?	x	—
Productus fernglenensis Weller ?	x	x
Productus sampsoni Weller	x	x
Productus sp. 1	x	—
Productus sp. 2	x	—
Pustula concentrica (Hall)	x	x
Rhipidomella diminutiva Rowley	x	?
Rhipidomella jerseyensis Weller	—	x
Schizophoria sedaliensis Weller ?	—	x

FAUNAL TABLE XXXI—Continued.

Beds	4	5
<i>Brachiopods—Cont'd</i>		
Schizophoria swallovi (Hall).....	x	—
Schizophoria sp.....	x	—
Camarophoria bisinuata (Rowley).....	—	x
Camarotoechia ? sp.....	x	—
Rhynchotetra elongatum Weller.....	—	x
Dielasma osceolense Weller.....	x	—
Dielasma sp.....	x	—
Spiriferina subtexta White.....	x	x
Spirifer gregeri Weller.....	x	?
Spirifer louisianensis Rowley.....	x	x
Spirifer forbesi N. & P.....	—	x
Spirifer shepardi Weller ?.....	x	—
Brachythyris chouteauensis Weller.....	x	x
Pseudosyrinx missouriensis Weller ?.....	x	—
Spiriferella ? schucherti Weller ?.....	x	—
Reticularia cooperensis (Swallow) ?.....	x	—
Reticularia sp.....	—	x
Ambocoelia levicula Rowley.....	x	—
Athyris lamellosa (L'Eveille).....	x	x
Cliothyridina tenuilineata (Rowley) ?.....	—	x
<i>Pelecypod</i>		
Undetermined.....	x	—
<i>Gastropods</i>		
Pleurotomaria ? sp.....	—	x
Straparollus ammon (W. & W.).....	x	—
Holopea sp.....	x	—
Orthonychia cornuforme (Winchell) ?.....	x	—
Igoceras pabulocrinum (Owen) ?.....	—	x
Igoceras sp.....	x	—
<i>Trilobite</i>		
Phillipsia ? tuberculata M. & W.....	—	x

The exposed beds of the Burlington (Lower) described in stratigraphic section 33, in Dark Hollow, near Fulton, in Callaway county were found to contain the following species:

XXXI-A. Fossils From the Lower Burlington Limestone in Dark Hollow Near Fulton, Mo., Sec. 28, T. 47 N., R. 9 W.

Corals

Zaphrentis aff. Z. centralis E. & H.
Zaphrentis sp.
Amplexus sp.

Syringopora sp.

Crinoids

Batocrinus sp.
Several undetermined species

Brachiopods

Chonetes illinoisensis Worthen
Productus ovatus Hall
Pustula alternata (N. & P.)
Rhipidomella sp.
Schizoporia swallovi (Hall)

Spiriferina subtexta White
Spirifer grimesi Hall
Spirifer louisianensis Rowley
Spirifer shepardii Weller
Spirifer osagensis Swallow
Brachythyris suborbicularis (Hall) ?

In the vicinity of Columbia, Boone county, rather sparingly fossiliferous crinoidal limestone, that seems to belong in part to Upper Burlington and in part to the Keokuk is observed. The writer did not undertake detailed stratigraphic classification of the rocks in this area which, at the doors of the University of Missouri, has long been under scrutiny of Dr. Branson and his colleagues. A section measured at a quarry in the south part of Columbia, west of the Missouri, Kansas and Texas railway, shows the general character of the rocks exposed here.

(42.) Section of Burlington Limestone in South Part of Columbia, Boone County

		Thickness	
		Feet.	Inches.
Osage group			
Burlington limestone (Upper)			
6.	Covered to top of hill.....	15	
5.	Limestone, light bluish gray to light buff, even texture, medium-grained, very massive, coarse crinoid fragments appear in some weathered layers, chert in lenticular nodules, discontinuous bands at intervals of about 3 feet. Contains <i>Triplophyllum dalei</i> (E. & H.), <i>Aulopora</i> sp., <i>Pustula alternata</i> (N. & P.), <i>Rhipidomella burlingtonensis</i> Hall, <i>Spirifer grimesi</i> Hall, and <i>Cliothyridina</i> sp.....	15	6
4.	Limestone, bluish to buff gray, color uneven, fine to medium-grained, massive, chert in large lenticular nodules up to 1 foot diameter or in thin bands at intervals of 6, inches to 2 feet, stylolites. Contains <i>Triplophyllum dalei</i> (E. & H.), <i>Cryptoblastus melo</i> (O. & S.) ?, <i>Rhipidomella burlingtonensis</i> Hall, <i>Cliothyridina incrassata</i> (Hall), <i>Composita globosa</i> Weller, and undetermined crinoids.....	8	4
3.	Limestone, dark bluish gray, weathering buff, impure, fine-grained, contains abundant chert in small nodules or thin bands, grades laterally into less cherty crystalline limestone..	1	6
2.	Limestone, dark bluish gray to nearly white, fine to medium-grained, very massive, cherty, crinoidal; contains <i>Pustula alternata</i> N. & P.....	5	
1.	Limestone, light bluish gray weathering buff, medium to coarse-grained, very massive, crinoidal, contains large stylolites. <i>Rhipidomella burlingtonensis</i> Hall, and <i>Spirifer grimesi</i> Hall common; <i>Triplophyllum dalei</i> (E. & H.), <i>Schizoporia swallovi</i> (Hall), <i>Dorycrinus</i> sp., <i>Platycrinus</i> sp. and a fish tooth observed.....	9	
	Covered to level of creek.....	10	

Strata belonging higher in the Osage, lithologically and on fragmentary faunal evidence, suggestive of the Keokuk occur in the environs of Columbia. From medium-grained, bluish gray cherty limestone 1 mile northeast of the town the following fossils were collected: *Pentremites elongatus* Shumard,

Pentremites sp., *Productus* n. sp., *Pustula* sp., *Camarotoechia* cf. *C. grosveneri* (Hall), *Spirifer rostellatus* Hall, *Spirifer* sp., *Reticularia* sp., and *Athyris lamellosa* (L'Eveille). A number of broken and unidentifiable crinoid calices were observed on the limestone floor of an old reservoir at this locality. Dr. Branson reports that *Pentremites elongatus* is characteristic of these upper beds near Columbia.

The Burlington limestone is almost continuously exposed in the bluffs north of Missouri river east of Rocheport. However, much of the formation is inaccessible and it is very difficult to collect fossils. A section measured about $\frac{3}{4}$ mile east of Rocheport shows the general character of the rocks.

(43) Section of Burlington Limestone 3-4 Mile East of Rocheport, Boone County

		Thickness Feet. Inches.	
Loess.....		19	
Osage group			
Burlington limestone (Upper and Lower)			
6.	Limestone, gray to buff, rather coarse-grained, crinoidal, thin to thick beds, somewhat uneven. Chert common, occurring in lenticular nodules and bands.....	68	
5.	Limestone, brown, magnesian, hard, compact, cherty, in thin uneven beds. Contains scattered crinoid fragments.....	14	
4.	Limestone, light gray, medium-grained, in beds 3 to 4 inches thick, very little chert, stylolites present, exposed.....	8	
3.	Limestone and chert, limestone in lower part is buff, medium-grained, crystalline, magnesian; chert appears in lenticular nodules and irregular bands alternating with limestone, the chert nearly equal in amount to the limestone (base of Upper Burlington ?).....	6	11
2.	Limestone, bluish gray, weathering light buff, medium to coarse-grained, crystalline, very massive showing no trace of bedding, large stylolites, non-cherty.....	19	6
1.	Limestone, light bluish gray to buff, medium-grained, crystalline, hard, contains little coarse crinoid material, stylolites, a small amount of chert present.....	16	6
	Covered to level of Missouri River.....	15	

XXXII. Fossils From the Burlington Limestone East of Rocheport, Boone County

Beds	2	4
<i>Corals</i>		
Zaphrentis sp.....	x	—
Triplophyllum dalei (E. & H.).....	x	x
Homalophyllum calceolum White ?.....	x	—
Amplexus fragilis White & St. John.....	—	x
<i>Crinoids</i>		
Batocrinus sp. 1, 2.....	x	—
Platycrinus sp.....	x	—

FAUNAL TABLE XXXII—Continued.

Beds	2	4
<i>Bryozoan</i>		
Fenestella sp.	x	—
<i>Brachiopods</i>		
Leptaena analoga (Phillips)	x	—
Schellwienella alternata Weller ?	x	—
Chonetes illinoisensis Worthen	—	x
Productus fernglenensis Weller ?	x	—
Productus sampsoni Weller	x	—
Productus viminalis White ?	x	—
Productus sp.	—	x
Pustula sp. cf. P. alternata (N. & P.)	—	x
Pustula sp.	x	—
Rhipidomella burlingtonensis (Hall)	?	x
Rhipidomella sp.	x	—
Schizophoria swallowi (Hall)	x	x
Rhynchotetra gibbosum (Greger)	x	—
Spiriferina subtexta White	x	—
Spirifer forbesi N. & P.	x	—
Spirifer grimesi Hall	x	x
Spirifer louisianensis Rowley	x	—
Spirifer incertus Hall ?	—	x
Spirifer sp. 1, 2	—	x
Syringothyris sp.	x	—
Ambocoelia levicula Rowley	x	—
Athyris lamellosa (L'Eveille)	x	x
Cliothyridina incrassata (Hall)	x	—

From white chert nodules occurring near the base of the upper Burlington (?) two miles northwest of Huntsdale on Missouri river below Rocheport the following fauna was collected:

XXXIII. Fauna from Chert Nodules in the Burlington, Two Miles Northwest of Huntsdale, Boone County

<i>Corals</i>	Spiriferina subtexta White
Zaphrentis sp.	Spirifer grimesi Hall
Triplophyllum dalei (E. & H.)	Spirifer incertus Hall ?
<i>Bryozoans</i>	Spirifer imbrex Hall ?
Fenestella sp. 1, 2, 3	<i>Pelecypods</i>
Cystodictya americana Ulrich	Aviculopecten sp.
Cystodictya lineata Ulrich	Pernopecten sp. cf. P. cooperensis
Coscinium latum Ulrich	(Shumard)
<i>Brachiopods</i>	<i>Gastropods</i>
Chonetes illinoisensis Worthen	Bucania sp.
Productus burlingtonensis Hall	Platyceras sp. 1, 2
Productus viminalis White	Igoceras capulum Keyes
Rhipidomella burlingtonensis (Hall)	<i>Trilobite</i>
Rhipidomella sp. cf. R. dubia (Hall)	Phillipsia ? sp.
Schizophoria swallowi (Hall)	

The Burlington limestone (Bed 19 of stratigraphic section 31, page 151) at Sweeney, Pettis county, contains the following fauna, representing clearly the lower division of the formation:

XXXIV. Fauna of the Lower Burlington Limestone at Sweeney, Pettis County. Sec. 4, T. 46 N., R. 19 W.

Corals

- Zaphrentis* sp.
- Triplophyllum dalei* (E. & H.) ?
- Homalophyllum calceolum* (White)

Bryozoan

- Fenestella* sp.

Brachiopods

- Leptaena analoga* (Phillips)
- Schellwienella* sp. cf. *S. burlingtonensis* Weller
- Chonetes glenparkensis* Weller
- Chonetes illinoisensis* Worthen
- Productus sampsoni* Weller
- Productus fernglenensis* Weller ?
- Productus* n. sp.
- Productus* sp.
- Pustula alternata* (N. & P.)
- Pustula arctifossa* Moore ?
- Pustula* sp.
- Rhipidomella burlingtonensis* Hall
- Rhipidomella jerseyensis* Weller ?
- Schizophoria swallowi* (Hall) ?
- Schizophoria poststriatula* Weller
- Camarophoria bisinuata* (Rowley)
- Shumardella missouriensis* (Shumard)
- Rhynchopora persinuata* (Winchell) ?
- Dielasma fernglenense* Weller ?

- Spiriferina subtexta* White ?
- Spirifer gregeri* Weller
- Spirifer grimesi* Hall
- Spirifer forbesi* N. & P.
- Spirifer louisianensis* Rowley
- Spirifer incertus* Hall ?
- Spirifer osagensis* Swallow
- Spirifer pikensis* Rowley ?
- Spirifer shepardii* Weller
- Brachythyris suborbicularis* (Hall) ?
- Syringothyris* sp.
- Pseudosyrinx missouriensis* Weller
- Reticularia* sp. cf. *R. cooperensis* (Swallow)
- Athyris lamellosa* (L'Eveille)
- Cliothyridina obmaxima* (McChesney)

Pelecypod

- Undetermined

Gastropods

- Straparollus latus* Hall
- Naticopsis* n. sp.
- Platyceras paraliun* W. & W.
- Igoceras pabulocrinum* (Owen) ?
- Igoceras* sp.
- Orthonychia* sp.

Trilobite

- Phillipsia* ? sp.

At Osceola, in St. Clair county, crinoidal limestone of typical Burlington aspect is observed. Above the beds mentioned an erosional break is indicated by the somewhat uneven upper surface of the limestone and the occurrence of a chert conglomerate at the base of the succeeding limestone. The pebbles in the conglomerate include several kinds of chert, many of the fragments being angular and showing on one side a somewhat porous, chalky weathering or a rim like that seen in some of the subjacent Mississippian rocks. Burlington, Kinderhook, and possibly older cherts may be recognized, but lithologic character and fossils show that most of the chert was derived from the Lower Burlington. Fossils partly weathered from the chert before redeposition project into the limestone matrix. The shapes, kinds and arrangement of the chert fragments show that this is a

true conglomerate, and it indicates a hiatus at this horizon. A large fauna beautifully preserved in chert nodules of Bed 4 of the following section clearly indicates the Lower Burlington age of the beds below the break. The less fossiliferous beds above are tentatively identified as Keokuk.

(44) Section at Quarry of Halliwell Cement Company, 1 Mile West of Osceola, St. Clair County

	Thickness Feet. Inches.
Osage group	
Keokuk (?) limestone	
6. Limestone, light gray to blue weathering buff, medium-grained, massive. The lower one or two feet consists of a chert conglomerate with angular pieces of more or less weathered chert in a matrix of limestone; the chert is clearly derived from older beds.	37
<i>Disconformity ?</i>	
Burlington limestone (Lower)	
5. Limestone, light bluish gray, medium to thin bedding, stylolites common, upper part distinctly crinoidal, chert in lower part, fossiliferous.	9
4. Limestone, gray, medium to coarse-grained, crystalline, crinoidal, very massive, contains large stylolites, white chert in nodules, fossils not abundant in limestone but numerous in the chert.	13
3. Limestone, blue, medium-grained, contains scattered crinoid fragments and calcite filled cavities, chert in upper part.	18-24
2. Limestone, light gray, coarse crystalline, crinoidal, stylolites common, large lenticular chert nodules at top.	2
1. Limestone, dark gray, coarse-grained, crystalline, crinoidal, a single massive layer, contains stylolites, exposed.	3

XXXV. Fossils from White Chert Nodules in Bed 4, Lower Burlington Limestone, West of Osceola

Corals

Zaphrentis sp. 1, 2, 3
Amplexus fragilis White & St. John
Amplexus blairi Miller
Amplexus sp.
Homalophyllum calceolum (White)
Monilopora sp.

Blastoids

Schizoblastus roemeri (Shumard)
Schizoblastus sampsoni (Hambach)
Orbitremites neglectus (M. & W.)
Cryptoblastus melo (O. & S.)

Crinoids

Platycrinus sp. cf. P. discoideus Owen & Shumard
Platycrinus sp. 1, 2
Crinoids undet.

Bryozoans

Leioclema sp.
Fistulipora ? sp.
Fenestella sp. 1, 2, 3, 4

Hemitrypa sp.

Lyropora sp.

Ptilopora ? sp.

Rhombopora sp.

Cystodictya sp.

Cyclopora ? sp.

Brachiopods

Leptaena analoga (Phillips)

Schuchertella n. sp.

Schellwienella burlingtonensis Weller

Schellwienella sp. 1, 2, 3

Streptorhynchus tenuicostatum Weller

Chonetes illinoisensis Worthen

Chonetes glenparkensis Weller

Chonetes multicostus Winchell

Productus sampsoni Weller ?

Productus fernglenensis Weller

Pustula concentrica (Hall)

Pustula arctifossa Moore

Pustula millespinosa (Girty) ?

Pustula sp.

- Rhipidomella thiemei* (White)
Rhipidomella jerseyensis Weller
Schizophoria subelliptica (W. & W.)
Schizophoria poststriatula Weller
Schizophoria sedaliensis Weller ?
Camarophoria bisinuata (Rowley)
Camarotoechia elegantula Rowley
Camarotoechia tuta (Miller)
Rhynchopora persinuata (Winchell)
Centronella ? *emaciata* Rowley
Centronelloidea rowleyi (Worthen)
Cranaena globosa Weller
Dielasma burlingtonense (White)
Cyrtina burlingtonensis (Rowley)
Spiriferina subtexta White
Spiriferina solidirostris White
Spirifer missouriensis Swallow
Spirifer shepardii Weller
Spirifer mundulus Rowley
Spirifer rowleyi Weller
Spirifer forbesi N. & P.
Spirifer vernonensis Swallow
Spirifer louisianensis Rowley
Brachythyris chouteauensis (Weller)
Syringothyris platypleurus Weller
Pseudosyrinx missouriensis Weller
Spiriferella ? *schucherti* Rowley
Reticularia cooperensis (Swallow)
Ptychospira sexplicata (W. & W.) ?
Eumetria perstrialis Rowley
Hustedia n. sp.
Nucleospira obesa Rowley
Athyris lamellosa (L'Eveille)
Cliothyridina tenuilineata (Rowley)
- Cliothyridina* sp.
Composita ? sp.
Pelecypods
Conocardium n. sp.
Conocardium sp.
Aviculopecten sp.
Pernopecten cooperensis (Shumard) ?
Pernopecten sp.
Pterinopecten sedaliensis Miller
Lithophagus ? sp. cf. *L. minutus* Weller
Cypricardina imbricata (Rowley)
Cypricardina n. sp.
Gastropods
Bellerophon blairi Miller ?
Bellerophon sp.
Pleurotomaria sp.
Pleurotomaria ? sp.
Platyschisma sp. cf. *P. depressa* Weller
Straparollus ammon (W. & W.)
Straparollus latus (Hall)
Platyceras paralum W. & W.
Platyceras sp. 1, 2
Orthonychia n. sp.
Orthonychia sp.
Lepetopsis sp.
Cephalopods
Orthoceras sp.
Muensteroceras ? *osagense* Swallow
Trilobites
Proetus swallovi Shumard ?
Phillipsia sampsoni Vogdes
Phillipsia tuberculata M. & W.
Griffithides ? *sedaliensis* Vogdes

XXXVI. Fossils from Bed 5 of the Lower Burlington Limestone, West of Osceola

- Corals*
Zaphrentis cliffordana (E. & H.) ?
Syringopora sp.
Bryozoans
Fenestella sp. 1, 2
Brachiopods
Chonetes illinoisensis Worthen ?
Chonetes glenparkensis Weller
Productus burlingtonensis Hall
Productus sampsoni Weller ?
Pustula sp.
Rhipidomella sp. cf. *R. jerseyensis* Weller
- Schizophoria poststriatula* Weller ?
Schizophoria sp.
Camarotoechia elegantula (Rowley) ?
Dielasma osceolense Weller
Spiriferina sp.
Spirifer grimesi Hall
Spirifer forbesi N. & P.
Spirifer louisianensis Rowley
Spirifer shepardii Weller
Gastropod
Straparollus latus (Hall)
Trilobite
Phillipsia tuberculata M. & W.

At Ash Grove in northwestern Greene county, massive, pure crinoidal limestone has been quarried extensively for

manufacture of lime. A section measured here shows the character and thickness of the exposed rocks. Fossils indicate the limestone at Ash Grove is not older than Upper Burlington. Most of the species occur in the Keokuk in southeastern Iowa but the presence of *Spirifer grimesi*, *Rhipidomella burlingtonensis*, *Schizophoria swallowi* and *Pentremites elongatus* which are common in the Upper Burlington but not in the Keokuk indicates that the beds at Ash Grove are in part of late Burlington age.

45. Section of Upper Burlington Limestone at Quarry of Ash Grove Lime and Portland Cement Company, 1 Mile West of Ash Grove, Greene County. Sec. 20,
T. 30 N., R. 24 W.

	Thickness Feet. Inches.	
Osage group		
Burlington limestone (Upper)		
5. Limestone, bluish gray, coarse crystalline, rather thin-bedded, crinoidal, contains <i>Spirifer grimesi</i> Hall, <i>Chonetes illinoisensis</i> Worthen, <i>Productus viminalis</i> White	7	6
4. Limestone like 5 but consists of a single massive bed; the lower 3 feet is very cherty, and 6 feet above the base is a zone of chert nodules. A zone filled with <i>Chonetes illinoisensis</i> Worthen occurs in the upper 1 foot. Large specimens of <i>Spirifer grimesi</i> Hall occur	12	
3. Limestone like 5 but somewhat finer in texture, massive, fossiliferous, stylolites common, nodular chert in zones 8, 10 and 12 feet from the top	23-23	
2. Limestone, yellowish to light brown, magnesian, medium-grained, massive	25	
1. Limestone, gray, coarse-grained, crystalline, massive, magnesian	26	

XXXVII. Fauna of the Upper Burlington Limestone at Ash Grove, Greene County

<i>Corals</i>		<i>Pustula alternata</i> (N. & P.)
<i>Zaphrentis</i> sp.		<i>Rhipidomella dubia</i> (Hall)
<i>Triplophyllum dalei</i> (E. & H.) ?		<i>Rhipidomella burlingtonensis</i> (Hall)
<i>Blastoid</i>		<i>Schizophoria swallowi</i> (Hall)
<i>Pentremites elongatus</i> (Shumard) ?		<i>Rhynchopora</i> ? sp.
<i>Crinoids</i>		<i>Spirifer grimesi</i> Hall
<i>Batocrinus</i> ? sp.		<i>Spirifer logani</i> Hall ?
<i>Barycrinus hoveyi</i> (Hall)		<i>Spiriferella plena</i> (Hall)
<i>Platycrinus</i> sp. 1, 2		<i>Reticularia pseudolineata</i> (Hall) ?
<i>Bryozoans</i>		<i>Athyris lamellosa</i> (L'Eveille)
<i>Fenestella</i> sp.		<i>Cliothyridina incrassata</i> (Hall)
<i>Polypora</i> sp.		<i>Cliothyridina</i> n. sp.
<i>Brachiopods</i>		<i>Cliothyridina parvirostra</i> (M. & W.)
<i>Orthotetes keokuk</i> Hall ?	<i>Gastropods</i>	
<i>Chonetes illinoisensis</i> Worthen	<i>Platyceras latum</i> Keyes ?	
<i>Productus viminalis</i> White ?	<i>Lepetopsis umbella</i> (Hall)	

Good exposures of the Burlington and overlying Keokuk and Warsaw are found in Springfield and vicinity. This area has been studied in some detail by Shepard⁴² and Weller.⁸⁴ The

writer measured sections of different parts of the succession and collected fossils which indicate the presence of Lower and Upper Burlington and of the younger beds mentioned, but his study of this section is incomplete. Weller distinguishes five faunal zones in the Burlington at Springfield as follows:

Zones of the Burlington at Springfield

5. Siliceous limestone, variable but generally finer-grained than beds above or below. Contains much chert that weathers to chalky powder.
4. Limestone, coarse, crinoidal, marked in part by robust size of fossils.
3. Limestone like 4, faunal characters intermediate between 2 and 4.
2. Limestone like 4.
1. Limestone, fine-grained gray or blue, hard, conchoidal fracture, contains scattered nodules of chert. In places appears to grade indistinctly into yellowish (Pierson) limestone below.

XXXVIII. Fossils from the Burlington Limestone at Springfield. (Weller)*

Zones		1	2	3	4	5
<i>Corals</i>						
LUK	Zaphrentis centralis E. & H.	—	x	x	x	—
U	Hadrophyllum glans White.	—	—	x	x	—
L	Syringopora harveyi White.	—	x	—	—	—
<i>Crinoids</i>						
U	Actinocrinus verrucosus Hall.	—	—	—	—	x
K	Agaricocrinus americanus Roemer.	—	—	—	—	x
L	Agaricocrinus planoconvexus Hall.	—	x	—	—	—
U	Uperocrinus pyriformis (Shumard) ?	—	x	—	—	—
U	Dichocrinus striatus O. & S.	—	x	x	—	—
U	Aorocrinus parvus (Shumard).	—	—	—	—	x
U	Eucladocrinus pleurovimeus White.	—	—	x	—	—
	Platycrinus sp.	—	x	—	—	—
<i>Brachiopods</i>						
L	Leptaena analoga (Phillips).	x	x	—	—	—
K	Orthotetes keokuk (Hall).	x	x	—	x	—
LU	Chonetes illinoisensis Worthen.	x	x	x	x	—
LU	Productus burlingtonensis Hall.	x	x	x	—	—
LUK	Productus ovatus Hall.	x	—	—	—	—
K	Productus setigerus Hall (?)	—	—	x	x	—
	Productus sp.	x	x	—	—	x
U	Pustula alternata (N. & P.)	x	—	x	x	—
LU	Rhipidomella burlingtonensis Hall.	x	x	x	x	—
LU	Schizophoria swallowi (Hall).	x	x	x	x	x
L	Dielasma burlingtonensis (Hall).	x	—	—	—	—
	Dielasma sp.	x	x	—	—	—
	Spiriferina sp.	x	—	—	—	—
Kd	Spirifer biplicatus.	x	—	—	—	—
L	Spirifer forbesi N. & P.	x	x	—	—	—

*Stratigraphic occurrence elsewhere is indicated as follows: Kd—Kinderhook, L—Lower Burlington, U—Upper Burlington, K—Keokuk.

FAUNAL TABLE XXXVIII—Continued.

Zones	1	2	3	4	5
<i>Brachiopods—Cont'd</i>					
LU <i>Spirifer grimesi</i> Hall.	x	x	x	x	x
K <i>Spirifer keokuk</i> Hall?	—	x	—	—	—
<i>Spirifer</i> sp.	—	x	—	x	—
LUK <i>Brachythyris suborbicularis</i> (Hall)	x	x	x	x	—
L <i>Syringothyris carteri</i> Hall.	x	—	—	—	—
U <i>Spiriferella plena</i> (Hall)	—	x	x	x	—
LUK <i>Reticularia pseudolineata</i> (Hall)	—	—	x	—	—
<i>Pelecypod</i>					
Kd <i>Pernopecten circulus</i> (Shumard)	x	—	—	—	—
<i>Gastropods</i>					
L <i>Phanerotinus paradoxus</i> Winchell.	x	—	—	—	—
UK <i>Platyceras equilaterum</i> Hall.	—	—	—	x	—
<i>Loxonema</i> sp.	x	—	—	—	—
U <i>Orthonychia quincyense</i> (McChesney)	—	—	x	x	—
LU <i>Pleurotomaria montezuma</i> Worthen.	—	x	—	—	—
L <i>Straparollus latus</i> (Hall)	—	x	—	—	—
U <i>Lepetopsis umbella</i> (Hall)	—	—	x	x	—
<i>Trilobites</i>					
K <i>Griffithides bufo</i> (M. & W.)	—	—	—	x	—
<i>Phillipsia</i> sp.	x	—	—	—	—

The widespread, lithologically distinctive subdivision of the Osage group in southwestern Missouri which is here termed the Reeds Spring limestone member of the Boone formation, lies conformably upon the St. Joe limestone and extends upward to the base of the Grand Falls chert. Its stratigraphic position shows that it is younger than strata of Fern Glen age and its contained fossils clearly indicate that the Reeds Spring limestone is older than Upper Burlington. It has commonly been called Lower Burlington, although its character is recognized as very unlike any part of the typical Burlington of other districts. The Reeds Spring is well exposed below Grand Falls on Shoal Creek, southwest of Joplin, and in this district its relations to the Grand Falls chert are clear. There also numerous exposures to the south and southeast, those along the railroad in the vicinity of Reeds Spring in Stone county being selected as a type of locality for the member.

Collections of fossils from the Reeds Spring limestone were secured by the writer on the south side of Shoal Creek, about 1 mile west of Grand Falls, (se $\frac{1}{4}$, se $\frac{1}{4}$, Sec. 29, T. 27 N., R. 33

W.), at a horizon about 10 feet below the base of the Grand Falls chert and at a place one and a quarter miles east of Crane, from the lower 40 feet of the formation. The faunas, reported in the following table, show a marked relationship with the Fern Glen and St. Joe on one hand and with the fauna of the Lower Burlington, especially as developed near Osceola, on the other. While it is desirable on lithologic, faunal and stratigraphic grounds to distinguish the limestone here described from other deposits of Osage age, it is believed that the Reeds Spring limestone is the time equivalent of at least a part of the lower division of the Burlington. It may be in part, or even entirely, slightly older than the Burlington. Certainly it appears to lack the abundant crinoids and other faunal elements that distinguish the typical Lower Burlington, the absence of these being due possibly to slight difference in age, difference in conditions of deposition or in part to inadequate study.

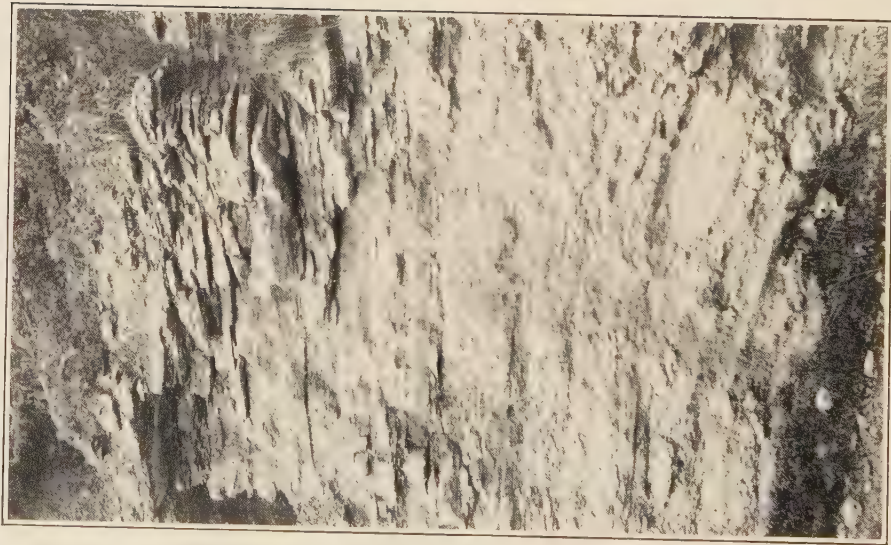
XXXIX. Fauna of the Reeds Spring Limestone on Shoal Creek Near Joplin and Near Crane

Localities	Shoal Creek	East of Crane
<i>Corals</i>		
Cyathaxonia minor Weller.....	—	x
Cyathaxonia arcuata Weller.....	—	x
Homalophyllum calceolum White ?.....	—	x
Zaphrentis sp.....	x	—
<i>Bryozoans</i>		
Fenestella rudis Ulrich ?.....	—	x
Fenestella sp. cf. F. triserialis Ulrich.....	—	x
Fenestella sp.....	x	x
Fenestella sp.....	—	x
Fenestella sp.....	—	x
Polypora sp.....	—	x
Evactinopora sexradiata M. & W.....	—	x
Cystodictya lineata Ulrich.....	—	x
Rhombopora sp.....	—	x
<i>Brachiopods</i>		
Schuchertella fernglenensis Weller ?.....	x	—
Schellwienella sp. cf. S. burlingtonensis Weller.....	x	—
Schellwienella sp. cf. S. sp. (Pierso nls.).....	x	—
Streptorhynchus n. sp.....	—	x
Chonetes illinoisensis Worthen.....	—	x
Chonetes burlingtonensis Weller ?.....	x	—
Chonetes ornatus var. arkansanus Girty.....	x	—
Chonetes n. sp.....	x	—

FAUNAL TABLE XXXIX—Continued.

Localities	Shoal Creek	East of Crane
<i>Brachiopods—Cont'd</i>		
Chonetes sp.	x	—
Productus ovatus Hall.	x	—
Productus fernglenensis Weller ?	x	—
Productus sampsoni Weller ?	x	—
Productus newtonensis Moore	x	—
Productus sp.	x	—
Pustula newarkensis Moore	x	—
Pustula n. sp. (P. concentrica Girty)	x	—
Pustula sp.	x	—
Rhipidomella jerseyensis Weller	x	—
Rhipidomella tenuicostata Weller	—	x
Schizophoria poststriatula Weller ?	x	—
Camarophoria bisinuata (Rowley)	x	—
Tetracamera subtrigona (M. & W.) ?	x	—
Rhynchopora persinuata (Winchell)	x	—
Dielasma ? sp.	x	—
Spiriferina subtexta White	—	x
Spirifer shepardi Weller	x	—
Spirifer rowleyi Weller	x	x
Spirifer louisianensis Rowley	x	x
Spirifer osagensis Swallow	x	—
Spirifer buehleri Moore	x	—
Brachythyris chouteauensis (Weller)	x	?
Brachythyris suborbicularis (Hall) ?	x	—
Pseudosyrinx sp. cf. P. keokuk Weller	x	—
Ptychospira sexplicata (W. & W.)	—	x
Reticularia cooperensis (Swallow)	x	—
Athyris lamellosa (L'Eveille)	x	x
Cliothyridina prouti (Swallow)	—	x
Cliothyridina tenuilineata (Rowley)	—	x
Cliothyridina glenparkensis Weller	x	—
Cliothyridina obmaxima (McChesney)	—	x
<i>Pelecypods</i>		
Edmondia ? sp.	x	—
Aviculopecten sp.	x	—
<i>Gastropod</i>		
Platyceras paralum W. & W.	—	x
<i>Trilobites</i>		
Phillipsia ? sp.	x	—
Griffithides sp.	—	x

An exposure of somewhat crinoidal limestone about half a mile northwest of Crane belongs to a higher horizon, as shown by the small collection of fossils obtained from it, and it may be correlated with the Upper Burlington.



A. Weathered outcrop of St. Joe limestone on Mo. Pac. R. R., 1 1/2 miles southeast of Reeds Spring, Stone County.



B. Cherty Reeds Spring limestone, 3 miles west of Crane, on Mo. Pac. R. R.

XL. Fossils from the Upper Burlington Limestone One-half Mile Northwest of Crane

Corals

Zaphrentis sp.

Triphophyllum dalei (E. & H.) ?

Blastoid

Schizoblastus sayi (Shumard)

Crinoids

Uperocrinus pyriformis (Shumard)

Aorocrinus parvus (Shumard) ?

Agaricocrinus coreyi Lyon & Cassedy ?

Eucladocrinus sp.

Brachiopods

Spirifer grimesi Hall ?

Spirifer sp.

Correlation. The distinctive lithologic character and faunal similarities show that the crinoidal Burlington limestone of Missouri is made up of the same elements as observed in the adjacent type region of southeastern Iowa. The strata are continuous beneath northern Missouri from outcrops in Iowa to exposures along Missouri river and to the northwest, west and southwest rocks of Burlington age extend an unknown distance under cover. Strata of corresponding age are known in the distant west. Judged by lithologic characters observed in drill cuttings the dark colored chert and bluish compact limestone of the Reeds Spring member of the Boone as seen in southwestern Missouri extend many miles beneath the plains of Kansas and Oklahoma. Coarser grained, light colored rocks, probably of Keokuk and Warsaw age are found above these dark beds, but in central and southern Oklahoma the dark colored "Mississippi lime" is regarded as Mayes (Meramecian and younger). As has already been noted, beds of early Osage age, probably including Lower Burlington, are widely distributed to the southeast, forming part of the Ft. Payne chert in Alabama.

Most important among the faunal elements of the Burlington are the crinoids. Not only is this class a main factor in rock-building but there are scores of species, a large proportion of which are restricted to this formation. Crinoids began to assume a front rank at the beginning of the Osage as shown by the rich crinoid faunas of the Fern Glen, New Providence, Lake Valley (New Mexico) LeGrand (Iowa) and Sedalia beds. The Burlington contains a record of the continuation and acceleration of crinoidal development, the clear, shallow waters of the Mississippi valley being apparently a region of maximum differentiation and dispersal of crinoids to other seas of the time. In structural and ornamental features the crinoids exhibit evolution along several lines, species of Burlington age being broadly distinguished from those of Keokuk and both of these from Warsaw types. The Osage epoch marks the culmination of the great

division of the crinoids known as *Camerata*, and it is remarkable that immediately following this maximum deployment the group almost completely vanished. Most of the crinoids recorded in the foregoing faunal lists are found in southeastern Iowa and are restricted to the Burlington. Many other Burlington crinoids have been found in Missouri (Rowley lists 130 specifically identified crinoids from the Burlington of Pike county) but to obtain a large number of specimens requires long continued and painstaking collection in specially favorable localities.

Among the other classes of fossils some species, such as *Leptaena analoga*, *Schizophoria swallowi* and *Spirifer louisianensis* are more or less common in earlier Mississippian rocks but do not range into the Keokuk. Some species, such as *Productus burlingtonensis*, *Rhipidomella burlingtonensis*, *Camarophoria bisinuata*, *Spirifer grimesi*, *S. forbesi*, *Spiriferella plena*, *Cryptoblastus melo*, *Orbitremites norwoodi* and several others are restricted to the Burlington and are characteristic. A third group of fossils including such forms as *Triplophyllum dalei*, *Pustula alternata*, *Brachythyris suborbicularis* and *Reticularia pseudolineata*, first appears in the Burlington but is common in later Osage beds. Comparison of the faunal lists in this and other parts of the present report show the distinctive features on which the Burlington is recognized in Missouri and other places where corresponding rocks are found.

The following faunal comparison of the early Osage formations that have been described not only shows the common and the differing elements but suggests the richness of fossil evidence on which conclusions are based. The faunal distinctions between beds of Fern Glen age, of Lower Burlington age and Upper Burlington age, respectively, appear in each of the biologic divisions but especially in the echinoderms and brachiopods. Equivalence of the Lower and Upper Burlington of Missouri to corresponding units in the type region of southeastern Iowa is clear. Some scores of Burlington fossils, not shown on the following list, are known to occur in central and northeastern Missouri and in Iowa; they are omitted because information concerning stratigraphic range within the formation is not at hand.

Faunal Table XLI. Comparison of the Faunas of the Lower Osage Formations and the Burlington Limestone*

Formations	Pierson	Sedalia	Fern Glen	St. Joe	Reeds Spring	Lower Burlington	Upper Burlington
<i>Corals</i>							
Cyathaxonia arcuata Weller.....	-	-	x	x	x	-	-
Cyathaxonia tantilla (Miller).....	-	x	-	-	-	-	-
Cyathaxonia minor Weller.....	-	-	x	x	x	-	-
Hadrophyllum glans (White).....	-	-	-	-	-	-	x
Hadrophyllum sp.....	-	x	-	-	-	-	-
Zaphrentis cliffordana E. & H.....	-	-	x	x	-	x	-
Zaphrentis exigua Miller.....	-	x	-	-	-	-	-
Zaphrentis elliptica White.....	-	-	-	-	-	x	-
Zaphrentis tenella Miller.....	x	x	-	-	-	-	-
Zaphrentis wortheni Weller.....	-	-	x	x	-	-	-
Zaphrentis sp. aff. Z. centralis E. & H.....	-	-	-	-	-	x	-
Zaphrentis calceola (W. & W.).....	-	-	-	-	-	-	x
Zaphrentis.....	x	-	x	x	x	x x	x x
Homalophyllum calceolum (W. & W.).....	-	x	-	-	?	x	-
Triplophyllum dalei (E. & H.).....	-	-	-	-	-	x x	x x
Amplexus radigerus Rowley.....	-	-	-	-	-	*	-
Amplexus archimediformis Rowley.....	-	-	-	-	-	*	-
Amplexus vermicularis Rowley.....	-	-	-	-	-	*	-
Amplexus blairi Miller.....	?	x	-	x	-	x	-
Amplexus brevis Weller.....	-	-	x	x	-	-	-
Amplexus fragilis W. & St. J.....	-	-	-	-	-	x	-
Amplexus rugosus Weller.....	-	-	x	?	-	-	-
Amplexus.....	-	x	-	x	-	x	-
Cyathophyllum glabrum Keyes.....	-	x	-	-	-	-	-
Chonophyllum sedaliense White.....	-	x	-	-	-	-	-
Beaumontia americana Weller.....	-	-	x	-	-	-	-
Favosites valmeyerensis Weller.....	-	-	x	-	-	-	-
Leptopora typa Winchell.....	-	x	-	-	-	-	-
Syringopora harveyi White.....	-	?	-	-	-	-	-
Syringopora sp.....	-	-	-	-	-	x	-
Cladochonus americanus Weller.....	-	-	x	x	-	x	-
Monilopora crassa (McCoy).....	-	-	x	-	-	-	-
Monilopora amplexa Rowley.....	-	-	-	-	-	*	-
Monilopora.....	-	x	-	-	-	x	-
Aulopora longi Rowley.....	-	-	-	-	-	*	*
Aulopora amplexa Rowley.....	-	-	-	-	-	-	*
<i>Crinoids</i>							
Rhodocrinus punctatus Weller.....	-	-	x	-	-	-	-
Rhodocrinus barrisi Hall.....	-	-	-	-	-	-	* x

*In this table occurrence of species in the Lower and Upper Burlington of the type region in southeastern Iowa are represented by *italics*, data from the lists of F. M. Van Tuyl (Ia. Geol. Surv., vol. 30) and in the crinoids from Stuart Weller (U. S. Geol. Surv., Bull. 153). Species reported on authority of R. R. Rowley (Mo. Bur. Geol. Mines, 2 ser., vol. 8) from Pike County, Mo., are indicated by (*) and of E. M. Shepard (Mo. Geol. Surv., vol. 12) from Greene County, Mo., by (†).

FAUNAL TABLE XLI—Continued.

Formations	Pierson	Sedalia	Fern Glen	St. Joe	Reeds Spring	Lower Burlington	Upper Burlington
<i>Crinoids—Cont'd</i>							
<i>Rhodocrinus barrisi striatus</i> W. & S.	-	-	-	-	-	-	- x
<i>Rhodocrinus truncatus</i> W. & S.	-	-	-	-	-	-	- x
<i>Rhodocrinus wachsmuthi</i> Hall.	-	-	-	-	-	x	-
<i>Rhodocrinus whitei</i> Hall.	-	-	-	-	-	* x	-
<i>Rhodocrinus wortheni</i> Hall.	-	-	-	-	-	* x	-
<i>Gilbertocrinus fiscellus</i> (M. & W.)	-	-	-	-	-	* x	-
<i>Gilbertocrinus obovatus</i> (M. & W.)	-	-	-	-	-	-	* x
<i>Gilbertocrinus reticulatus</i> (Hall)	-	-	-	-	-	* x	-
<i>Gilbertocrinus tenuiradiatus</i> (M. & W.)	-	-	-	-	-	x	-
<i>Gilbertocrinus tuberculosus</i> (Hall)	-	-	-	-	-	-	* x
<i>Gilbertocrinus</i> sp.	-	-	-	-	-	x	-
<i>Periechocrinus tenuidiscus</i> (Hall)	-	-	-	-	-	- x	-
<i>Periechocrinus whitei</i> (Hall)	-	-	-	-	-	- x	- x
<i>Megistocrinus evansii</i> (O. & S.)	-	-	-	-	-	* x	* x
<i>Megistocrinus evansi crassus</i> White.	-	-	-	-	-	- x	-
<i>Batocrinus aequalis</i> (Hall)	-	-	-	-	-	* x	-
<i>Batocrinus calvini</i> Rowley.	-	-	-	-	-	*	-
<i>Batocrinus clypeatus</i> (Hall)	-	-	-	-	-	* x	x -
<i>Batocrinus laura</i> (Hall)	-	-	-	-	-	-	- x
<i>Batocrinus laura sinuosus</i> (Hall)	-	-	-	-	-	-	- x
<i>Batocrinus lepidus</i> (Hall)	-	-	-	-	-	* x	-
<i>Batocrinus grandis</i> W. & S.	-	-	-	-	-	-	- x
<i>Batocrinus pistillus</i> (M. & W.)	-	-	-	-	-	-	- x
<i>Batocrinus quasillus</i> M. & W.	-	-	-	-	-	* x	-
<i>Batocrinus rotadentus</i> Rowley & Hare.	-	-	-	-	-	*	-
<i>Batocrinus shepardi</i> Rowley.	-	-	-	-	-	-	† -
<i>Batocrinus subaequalis</i> (McChesney)	-	-	-	-	-	* x	-
<i>Batocrinus turbinatus</i> (Hall)	-	-	-	-	-	* x	-
<i>Eretmocrinus calyculoides</i> (Hall)	-	-	-	-	-	-	* x
<i>Eretmocrinus calyculoides nodosus</i> W. & S.	-	-	-	-	-	-	- x
<i>Eretmocrinus clio</i> (Hall)	-	-	-	-	-	- x	x -
<i>Eretmocrinus cloelia</i> (Hall)	-	-	-	-	-	-	- x
<i>Eretmocrinus corbulis</i> (Hall)	-	-	-	-	-	- x	-
<i>Eretmocrinus coronatus</i> (Hall)	-	-	-	-	-	* x	-
<i>Eretmocrinus depressus</i> Keyes.	-	-	-	-	-	-	- x
<i>Eretmocrinus leucosia</i> (Hall)	-	-	-	-	-	* x	-
<i>Eretmocrinus matutus</i> (Hall)	-	-	-	-	-	-	- x
<i>Eretmocrinus minor</i> W. & S.	-	-	-	-	-	-	- x
<i>Eretmocrinus neglectus</i> (M. & W.)	-	-	-	-	-	- x	-
<i>Eretmocrinus remibrachiatus</i> (Hall)	-	-	-	-	-	-	- x
<i>Eretmocrinus brevis</i> Rowley.	-	-	-	-	-	-	*
<i>Eretmocrinus parvus</i> Rowley.	-	-	-	-	-	*	-
<i>Eretmocrinus nodosus</i> Rowley.	-	-	-	-	-	-	* -
<i>Eretmocrinus remibrachiatus expansus</i> W. & S. ...	-	-	-	-	-	-	- x
<i>Eretmocrinus rugosus</i> W. & S.	-	-	-	-	-	- x	-
<i>Macrocrinus carica</i> (Hall)	-	-	-	-	-	*	- x

FAUNAL TABLE XLI—Continued.

Formations	Pierson	Sedalia	Fern Glen	St. Joe	Reeds Spring	Lower Burlington	Upper Burlington
<i>Crinoids—Cont'd</i>							
Macrocrinus gemmiformis (Hall).....	-	-	-	-	-	x	-
Macrocrinus konincki (Shumard).....	-	-	-	-	-	-	* x
Macrocrinus verneuillianus (Shumard).....	-	-	-	-	-	-	* x
Dizygocrinus andrewsianus (McChesney).....	-	-	-	-	-	-	x x
Dizygocrinus dodecadactylus (M. & W.).....	-	-	-	-	-	-	- x
Dizygocrinus rotundus (Shumard).....	-	-	-	-	-	-	- x
Eutrochocrinus christyi (Shumard).....	-	-	-	-	-	-	x x
Eutrochocrinus christyi trochiscus (M. & W.)....	-	-	-	-	-	-	† x
Eutrochocrinus lovei (W. & S.).....	-	-	-	-	-	-	x x
Uperocrinus aequibrachiatus (McChesney).....	-	-	-	-	-	-	* x
Uperocrinus aequibrachiatus asteriscus (M. & W.)	-	-	-	-	-	-	x x
Uperocrinus bulbosus (Rowley).....	-	-	-	-	-	*	-
Uperocrinus hageri (McChesney).....	-	-	-	-	-	-	x x
Uperocrinus dubius (Rowley).....	-	-	-	-	-	*	-
Uperocrinus inflatus (Rowley & Hare).....	-	-	-	-	-	*	-
Uperocrinus insolitus (Rowley).....	-	-	-	-	-	*	-
Uperocrinus longirostris (Hall).....	-	-	-	-	-	* x	-
Uperocrinus nashvillae (Troost).....	-	-	-	-	-	-	† -
Uperocrinus nashvillae subtractus (White).....	-	-	-	-	-	-	† x
Uperocrinus pistilliformis (M. & W.).....	-	-	x	-	-	-	-
Uperocrinus pyriformis (Shumard).....	-	-	-	-	-	-	* x
Aorocrinus canaliculatus (M. & W.).....	-	-	-	-	-	- x	-
Aorocrinus concavus (M. & W.).....	-	-	-	-	-	- x	-
Aorocrinus elegans (Miller).....	-	-	-	-	-	-	- x
Aorocrinus parvus (Shumard).....	-	-	-	-	-	-	x x
Aorocrinus subaculeatus (Hall).....	-	-	-	-	-	* x	-
Aorocrinus wachsmuthi Rowley.....	-	-	-	-	-	*	-
Dorycrinus cornigerus (Hall).....	-	-	-	-	-	-	* x
Dorycrinus intermedius (M. & W.).....	-	-	-	-	-	-	* x
Dorycrinus missouriensis (Shumard).....	-	-	-	-	-	-	x x
Dorycrinus quinquelobus (Hall).....	-	-	-	-	-	-	- x
Dorycrinus roemerii M. & W.	-	-	-	-	-	-	* x
Dorycrinus subturbinatus (M. & W.).....	-	-	-	-	-	-	- x
Dorycrinus unicornis (Owen & Shumard).....	-	-	-	-	-	* x	-
Agaricocrinus brevis (Hall).....	-	-	-	-	-	* x	-
Agaricocrinus bullatus Hall.....	-	-	-	-	-	-	* x
Agaricocrinus convexus Hall.....	-	-	-	-	-	-	- x
Agaricocrinus coreyi (Lyon & Casseday).....	-	-	-	-	-	-	x -
Agaricocrinus excavatus Hall.....	-	-	-	-	-	-	- x
Agaricocrinus fiscellus (Hall).....	-	-	-	-	-	x x	-
Agaricocrinus gracilis M. & W.	-	-	-	-	-	-	* x
Agaricocrinus inflatus Hall.....	-	-	-	-	-	-	* x
Agaricocrinus louisianensis Rowley.....	-	-	-	-	-	*	-
Agaricocrinus nodosus M. & W.	-	-	-	-	-	-	- x
Agaricocrinus ornatrema Hall.....	-	-	-	-	-	-	- x
Agaricocrinus ornatrema major W. & S.	-	-	-	-	-	-	- x

FAUNAL TABLE XLI—Continued.

Formations	Pierson	Sedalia	Fern Glen	St. Joe	Reeds Spring	Lower Burlington	Upper Burlington
<i>Crinoids—Cont'd</i>							
<i>Agaricocrinus planoconvexus</i> Hall.....	-	-	-	-	-	x x	- -
<i>Agaricocrinus praecursus</i> Rowley.....	-	-	x	-	-	- -	- -
<i>Agaricocrinus pyramidatus</i> (Hall).....	-	-	-	-	-	* x	- -
<i>Agaricocrinus stellatus</i> Hall.....	-	-	-	-	-	- -	* x
<i>Amphoracrinus divergens</i> (Hall).....	-	-	-	-	-	* x	- -
<i>Amphoracrinus spinobrachiatus</i> (Hall).....	-	-	-	-	-	* x	- -
<i>Actinocrinus asperrimus</i> (M. & W.).....	-	-	-	-	-	- x	- -
<i>Actinocrinus arrosus</i> (Miller).....	-	-	-	x	-	- -	- -
<i>Actinocrinus gracilis</i> W. & S.....	-	-	-	-	-	- x	- -
<i>Actinocrinus griffithi</i> W. & S.....	-	-	-	-	-	- -	- x
<i>Actinocrinus multiradiatus</i> Shumard.....	-	-	-	-	-	- -	† x
<i>Actinocrinus penicillus</i> (M. & W.).....	-	-	-	-	-	- x	- -
<i>Actinocrinus scitulus</i> M. & W.....	-	-	-	-	-	* -	? x
<i>Actinocrinus rubrus</i> Weller.....	-	-	x	-	-	- -	- -
<i>Actinocrinus tenuisculptus</i> McChesney.....	-	-	-	-	-	- x	- -
<i>Actinocrinus tuberculosus</i> W. & S.....	-	-	-	-	-	- -	- x
<i>Actinocrinus verrucosus</i> Hall.....	-	-	-	-	-	- -	x x
<i>Actinocrinus</i> sp.....	-	x	-	-	-	- -	- -
<i>Steganocrinus araneoleus</i> (M. & W.).....	-	-	-	-	-	* x	- -
<i>Steganocrinus concinnus</i> (Shumard).....	-	-	-	-	-	- -	* x
<i>Steganocrinus pentagonus</i> (Hall).....	-	-	-	-	-	* x	* -
<i>Steganocrinus sculptus</i> (Hall).....	-	-	-	-	-	* x	- -
<i>Cactocrinus clarus</i> (Hall).....	-	-	-	-	-	* x	- -
<i>Cactocrinus coelatus</i> (Hall).....	-	-	-	-	-	* x	- -
<i>Cactocrinus coelatus spinotentaculus</i> (Hall).....	-	-	-	-	-	- x	- -
<i>Cactocrinus denticulatus</i> W. & S.....	-	-	-	-	-	- x	- -
<i>Cactocrinus ectypus</i> (M. & W.).....	-	-	-	-	-	- x	- -
<i>Cactocrinus extensus</i> W. & S.....	-	-	-	-	-	- x	- -
<i>Cactocrinus glans</i> (Hall).....	-	-	-	-	-	- -	* x
<i>Cactocrinus limabrachiatus</i> (Hall).....	-	-	-	-	-	- x	- -
<i>Cactocrinus longus</i> (M. & W.).....	-	-	-	-	-	- x	- -
<i>Cactocrinus lucina</i> (Hall).....	-	-	-	-	-	- x	- -
<i>Cactocrinus multibrachiatus</i> (Hall).....	-	-	-	-	-	- x	- -
<i>Cactocrinus obesus</i> Keyes.....	-	-	-	-	-	- -	* ?
<i>Cactocrinus opusculus</i> (Hall).....	-	-	-	-	-	- x	- -
<i>Cactocrinus proboscidalis</i> (Hall).....	-	-	-	-	-	* x	- -
<i>Cactocrinus reticulatus</i> (Hall).....	-	-	-	-	-	- x	- -
<i>Cactocrinus reticulatus ovatus</i> (Hall).....	-	-	-	-	-	- x	- -
<i>Cactocrinus sexarmatus</i> (Hall).....	-	-	-	-	-	- x	- -
<i>Cactocrinus springeri</i> (Rowley).....	-	-	-	-	-	* -	- -
<i>Cactocrinus thalia</i> (Hall).....	-	-	-	-	-	- x	- -
<i>Teleiocrinus adolescens</i> W. & S.....	-	-	-	-	-	- x	- -
<i>Teleiocrinus althaea</i> (Hall).....	-	-	-	-	-	- -	- x
<i>Teleiocrinus liratus</i> (Hall).....	-	-	-	-	-	- -	* x
<i>Teleiocrinus rudis</i> (Hall).....	-	-	-	-	-	- -	- x
<i>Teleiocrinus tenuiradiatus</i> (Hall).....	-	-	-	-	-	- -	- x

FAUNAL TABLE XLI—Continued.

Formations	Pierson	Sedalia	Fern Glen	St. Joe	Reeds Spring	Lower Burlington	Upper Burlington
<i>Crinoids—Cont'd</i>							
Teleocrinus umbrosus (Hall).....	-	-	-	-	-	-	* x
Physetocrinus asper M. & W.....	-	-	-	-	-	-	- x
Physetocrinus dilatatus M. & W.....	-	-	-	-	-	-	- x
Physetocrinus ornatus (Hall).....	-	-	-	-	-	* x	-
Physetocrinus ventricosus (Hall).....	-	-	-	-	-	* x	* x
Physetocrinus smalleyi Weller.....	-	-	x	-	-	-	-
Strotocrinus glyptus (Hall).....	-	-	x	-	-	-	* x
Strotocrinus regalis (Hall).....	-	-	-	-	-	-	x x
Platycrinus acclivus Miller.....	-	?	-	-	-	-	-
Platycrinus aequalis Hall.....	-	-	-	-	-	-	- x
Platycrinus altidorsatus Rowley & Hare.....	-	-	-	-	-	-	*
Platycrinus americanus Owen & Shumard.....	-	-	-	-	-	* x	-
Platycrinus asper M. & W.....	-	-	-	-	-	-	* x
Platycrinus burlingtonensis Owen & Shumard.....	-	-	-	-	-	* x	-
Platycrinus canaliculatus Hall.....	-	-	-	-	-	- x	-
Platycrinus cavus Hall.....	-	-	-	-	-	-	x x
Platycrinus corbuliformis Rowley & Hare.....	-	-	-	-	-	* x	-
Platycrinus discoideus Owen & Shumard.....	-	-	-	-	-	* x	-
Platycrinus eminulus Hall.....	-	-	-	-	-	- x	-
Platycrinus excavatus Hall.....	-	-	-	-	-	* x	-
Platycrinus geometricus W. & S.....	-	-	-	-	-	-	- x
Platycrinus glyptus Hall.....	-	-	-	-	-	-	- x
Platycrinus gorbyi Miller.....	-	-	-	-	-	- x	-
Platycrinus halli Shumard.....	-	-	-	-	-	-	- x
Platycrinus incomptus White.....	-	-	-	-	-	-	* x
Platycrinus marginatus Rowley & Hare.....	-	-	-	-	-	-	*
Platycrinus nodostriatus W. & S.....	-	-	-	-	-	-	- x
Platycrinus ornogranulus McChesney.....	-	-	-	-	-	- x	-
Platycrinus parvinodus Hall.....	-	-	-	-	-	- x	-
Platycrinus pileiformis Hall.....	-	-	-	-	-	* x	-
Platycrinus pisum Rowley & Hare.....	-	-	-	-	-	*	-
Platycrinus planus Owen & Shumard.....	-	-	-	-	-	* x	? ?
Platycrinus pocilliformis Hall.....	-	-	-	-	-	* x	-
Platycrinus pratteni Worthen.....	-	-	-	-	-	- x	-
Platycrinus quinquenodus White.....	-	-	-	-	-	-	- x
Platycrinus regalis Hall.....	-	-	-	-	-	* x	-
Platycrinus scobinus M. & W.....	-	-	-	-	-	* x	-
Platycrinus sculptus Hall.....	-	-	-	-	-	- x	-
Platycrinus spinifer W. & S.....	-	-	-	-	-	- x	-
Platycrinus spinifer elongatus W. & S.....	-	-	-	-	-	- x	-
Platycrinus springeri Weller.....	-	-	x	-	-	-	-
Platycrinus stellatus Weller.....	-	-	x	-	-	-	-
Platycrinus subspinosus Hall.....	-	-	-	-	-	* x	-
Platycrinus subspinulosus Hall.....	-	-	-	-	-	-	- x
Platycrinus tenuibrachiatus M. & W.....	-	-	-	-	-	-	- x
Platycrinus truncatulus Hall.....	-	-	-	-	-	- x	-

FAUNAL TABLE XLI—Continued.

Formations	Pierson	Sedalia	Fern Glen	St. Joe	Reeds Spring	Lower Burlington	Upper Burlington
<i>Crinoids—Cont'd</i>							
Platycrinus verrucosus White.....	-	-	-	-	-	x	-
Platycrinus wortheni Hall.....	-	-	-	-	-	x	-
Platycrinus yandelli Owen & Shumard.....	-	-	-	-	-	x	-
Platycrinus yandelli perasper M. & W.....	-	-	-	-	-	x	-
Platycrinus saffordi Hall.....	-	-	-	-	-	-	† x
Eucladocrinus pleurovimeus (White).....	-	-	-	-	-	-	x x
Eucladocrinus praeununtius (W. & S.).....	-	-	-	-	-	-	* x
Eucladocrinus millebrachiatus W. & S.....	-	-	-	-	-	-	* x
Eucladocrinus millebrachiatus immaturus W. & S.....	-	-	-	-	-	-	- x
Eucladocrinus tuberosus (Hall).....	-	-	-	-	-	-	* x
Forbesiocrinus burlingtonensis Springer.....	-	-	-	-	-	-	- x
Forbesiocrinus agassizi Hall.....	-	-	-	-	-	-	- x
Mespilocrinus konincki (Hall).....	-	-	-	-	-	x	-
Mespilocrinus thiemei Springer.....	-	-	-	-	-	x	-
Mespilocrinus chapmani Springer.....	-	-	-	-	-	-	- x
Dichocrinus angustus White.....	-	-	-	-	-	-	- x
Dichocrinus conus M. & W.....	-	-	-	-	-	x	-
Dichocrinus crassitestus White.....	-	-	-	-	-	-	- x
Dichocrinus delicatus W. & S.....	-	-	-	-	-	x	-
Dichocrinus lachrymosus Hall.....	-	-	-	-	-	-	- x
Dichocrinus laevis Hall.....	-	-	-	-	-	x	-
Dichocrinus lineatus M. & W.....	-	-	-	-	-	* x	-
Dichocrinus liratus Hall.....	-	-	-	-	-	-	- x
Dichocrinus ovatus Owen & Shumard.....	-	-	-	-	-	x	-
Dichocrinus pendens W. & S.....	-	-	-	-	-	-	- x
Dichocrinus pisum M. & W.....	-	-	-	-	-	x	* -
Dichocrinus plicatus Hall.....	-	-	-	-	-	-	- x
Dichocrinus scitulus Hall.....	-	-	-	-	-	x	- x
Dichocrinus striatus Owen & Shumard.....	-	-	-	-	-	-	* x
Nipterocrinus arboreus (Worthen).....	-	-	-	-	-	x	-
Nipterocrinus wachsmuthi M. & W.....	-	-	-	-	-	-	- x
Ichthyocrinus nobilis W. & S.....	-	-	-	-	-	-	- x
Ichthyocrinus burlingtonensis Hall.....	-	-	-	-	-	* x	-
Metichthyocrinus burlingtonensis (Hall).....	-	-	?	-	-	x	-
Taxocrinus thiemei (Hall).....	-	-	-	-	-	* x	-
Onychocrinus diversus M. & W.....	-	-	-	-	-	-	- x
Synbathocrinus brevis M. & W.....	-	-	-	-	-	* x	-
Synbathocrinus dentatus Owen & Shumard.....	-	-	x	-	-	-	* -
Synbathocrinus wachsmuthi M. & W.....	-	-	-	-	-	-	- x
Synbathocrinus wortheni Hall.....	-	-	-	-	-	*	-
Halysiocrinus ventricosus Hall.....	-	-	-	-	-	*	-
Catillocrinus wachsmuthi (M. & W.).....	-	-	-	-	-	-	* x
Belemnocrinus florifer W. & S.....	-	-	-	-	-	-	- x
Belemnocrinus portalesi W. & S.....	-	-	-	-	-	x	-
Belemnocrinus typus White.....	-	-	-	-	-	-	- x
Belemnocrinus whitii M. & W.....	-	-	-	-	-	x	-

FAUNAL TABLE XLI—Continued.

Formations	Pierson	Sedalia	Fern Glen	St. Joe	Reeds Spring	Lower Burlington	Upper Burlington
<i>Crinoids—Cont'd</i>							
Parisocrinus perplexus (M. & W.)	-	-	-	-	-	x	-
Parisocrinus salignoides (White)	-	-	-	-	-	-	-
Barycrinus sculptilis (Hall)	-	-	-	-	-	-	x
Barycrinus hoveyi (Hall)	-	-	-	-	-	-	x
Barycrinus sp.	-	-	x	-	-	-	-
Atelestocrinus delicatus W. & S.	-	-	-	-	-	x	-
Cyathocrinus barydactylus W. & S.	-	-	-	-	-	-	x
Cyathocrinus formosus Rowley	-	-	-	-	-	*	-
Cyathocrinus fragilis M. & W.	-	-	-	-	-	x	-
Cyathocrinus gilesi W. & S.	-	-	-	-	-	-	* x
Cyathocrinus iowensis Owen & Shumard	-	-	-	-	-	-	* x
Cyathocrinus rigidus White	-	-	-	-	-	x	-
Cyathocrinus tenuidactylus (M. & W.)	-	-	-	-	-	x	-
Cyathocrinus sp.	-	-	-	x	-	-	-
Poteriocrinus notabilis (M. & W.)	-	-	-	-	-	x	-
Poteriocrinus obuncus White	-	-	-	-	-	x	-
Poteriocrinus waltersi Rowley & Hare	-	-	-	-	-	*	-
Poteriocrinus sp.	-	-	x	-	-	-	-
Woodocrinus asper (M. & W.)	-	-	-	-	-	-	x
Woodocrinus bursaeformis (White)	-	-	-	-	-	x	-
Woodocrinus elegans (Hall)	-	-	-	-	-	* x	-
Woodocrinus perangulatus (White)	-	-	-	-	-	-	x
Woodocrinus scobinus (M. & W.)	-	-	-	-	-	-	x
Woodocrinus troostanus (M. & W.)	-	-	-	-	-	-	* x
Coeliocrinus lyra (M. & W.)	-	-	-	-	-	-	x
Decadocrinus fiscellus (M. & W.)	-	-	-	-	-	x	-
Decadocrinus juvenis (M. & W.)	-	-	-	-	-	x	-
Decadocrinus scalaris (M. & W.)	-	-	-	-	-	-	x
Scytalocrinus macrodactylus (M. & W.)	-	-	-	-	-	x	-
Graphiocrinus rudis (M. & W.)	-	-	-	-	-	-	x
Graphiocrinus striatus (M. & W.)	-	-	-	-	-	x	-
Graphiocrinus sampsoni Weller	-	-	x	-	-	-	-
Erisocrinus antiquus M. & W.	-	-	-	-	-	x	-
Erisocrinus whitei M. & W.	-	-	-	-	-	-	x
Vasocrinus macropleurus (Hall)	-	-	x	-	-	-	-
<i>Blastoids</i>							
Codaster gracillimus Rowley & Hare	-	-	-	-	-	*	-
Codaster grandis Rowley & Hare	-	-	-	-	-	-	*
Codaster laeviculus Rowley	-	-	-	-	-	-	*
Codaster superbus Rowley	-	-	-	-	-	-	*
Orophocrinus campanulatus (Hambach)	-	-	-	-	-	x	-
Orophocrinus gracilis (M. & W.)	-	-	-	-	-	x	-
Orophocrinus sirius (White)	-	-	-	-	-	-	x
Orophocrinus stelliformis (O. & S.)	-	-	-	-	-	x x	-
Orophocrinus stelliformis cactus (Rowley)	-	-	-	-	-	*	-
Pentremites burlingtonensis M. & W.	-	-	-	-	-	-	x

FAUNAL TABLE XLI—Continued.

Formations	Pierson	Sedalia	Fern Glen	St. Joe	Reeds Spring	Lower Burlington	Upper Burlington
<i>Blastoids—Cont'd</i>							
Pentremites elongatus Shumard.....	-	-	-	-	-	-	x x
Pentremites decussatus Shumard.....	-	-	x	-	-	-	-
Metablastus lineatus (Shumard).....	-	-	-	-	-	*	* x
Schizoblastus roemeri (Shumard).....	-	x	-	x	-	x	-
Schizoblastus melonoides (M. & W.).....	-	-	-	-	-	-	- x
Schizoblastus sayi (Shumard).....	-	-	-	-	-	*	x x
Schizoblastus sampsoni (Hambach).....	-	x	-	-	-	x	-
Orbitremites concinnulus (Rowley & Hare).....	-	-	-	-	-	*	-
Orbitremites exiguus (Rowley & Hare).....	-	-	-	-	-	*	-
Orbitremites calycinus (Rowley).....	-	-	-	-	-	-	*
Orbitremites neglectus (M. & W.).....	-	-	-	-	-	x x	-
Orbitremites norwoodi (Owen & Shumard).....	-	-	-	-	-	x	x x
Orbitremites shumardi (M. & W.).....	-	-	-	-	-	- x	-
Cryptoblastus melo (Owen & Shumard).....	-	-	-	-	-	x x	-
Cryptoblastus pisum (M. & W.).....	-	-	-	-	-	-	- x
Carpenteroblastus magnibasis (Rowley).....	-	-	-	-	-	-	* -
Carpenteroblastus pyriformis (R. & H.).....	-	-	-	-	-	-	* -
Carpenteroblastus pentagonus Rowley.....	-	-	-	-	-	*	-
Carpenteroblastus stella (Rowley).....	-	-	-	-	-	-	* -
Lophoblastus marginulus Rowley.....	-	-	-	-	-	*	-
Lophoblastus aplatus (Rowley & Hare).....	-	-	-	-	-	-	* -
Lophoblastus inopinatus (Rowley & Hare).....	-	-	-	-	-	*	-
Lophoblastus conoideus Rowley.....	-	x	-	-	-	-	-
<i>Echinoids</i>							
Archaeocidaris agassizi Hall.....	-	-	-	-	-	*	-
Archaeocidaris sp.	-	-	-	-	-	x	-
<i>Bryozoans</i>							
Fistulipora fernglenensis Weller.....	-	-	x	x	-	-	-
Cheilotrypa sp.	-	-	-	x	-	-	-
Cheilotrypa americana Miller.....	-	-	x	-	-	-	-
Meekopora sp.	-	-	-	-	-	x	-
Leioclema.....	-	x	-	-	-	x	-
Fenestella burlingtonensis Ulrich.....	-	-	-	-	-	*	- x
Fenestella rudis Ulrich.....	-	x	-	-	?	-	-
Fenestella serratula Ulrich.....	-	-	-	-	-	- x	- x
Fenestella sp. cf. F. triserialis Ulrich.....	-	-	-	-	x	-	-
Fenestella.....	x	x	-	x	x	x	x -
Hemitrypa sp.	-	-	-	-	-	x	-
Lyropora retrorsa M. & W.....	-	-	-	-	-	*	-
Lyropora sp.	-	-	-	-	-	x	-
Polypora burlingtonensis Ulrich.....	-	-	-	-	-	*	-
Polypora.....	x	-	-	-	x	-	-
Pinnatopora.....	-	x	-	x	-	-	-
Ptilopora.....	-	x	-	-	-	x	-
Rhombopora gracilis Ulrich.....	-	-	-	-	-	-	- x
Rhombopora.....	-	x	-	x	-	x	-
Cystodictya americana Ulrich.....	-	-	-	-	-	?	x -

FAUNAL TABLE XLI—Continued.

Formations	Pierson	Sedalia	Fern Glen	St. Joe	Reeds Spring	Lower Burlington	Upper Burlington
<i>Bryozoans—Cont'd</i>							
Cystodictya lineata Ulrich	—	—	x	x	x	—	x —
Cystodictya	x	x	—	x	—	x —	— x
Coscinium latum Ulrich	—	—	—	—	—	*	x x
Evactinopora grandis M. & W.	—	—	—	—	—	*	— ?
Evactinopora sexradiata M. & W.	—	—	x	x	x	*	—
Glyptopora	—	—	—	—	—	x —	x —
Cyclopora sp.	—	—	—	—	—	?	—
<i>Brachiopods</i>							
Crania missouriensis Weller	—	—	x	—	—	—	—
Leptaena analoga (Phillips)	x	x	x	x	—	x x	—
Leptaena convexa Weller	—	x	—	—	—	?	—
Schuchertella fernglenensis (Weller)	—	?	x	x	?	—	—
Schuchertella n. sp.	—	—	—	—	—	x —	—
Schellwienella burlingtonensis Weller	—	—	—	—	cf	x —	—
Schellwienella inaequalis (Hall)	—	x	—	—	—	—	—
Schellwienella inflata (W. & W.)	cf	?	—	—	—	—	—
Schellwienella alternata Weller	—	—	—	—	—	?	—
Schellwienella chouteauensis Weller	—	—	—	—	—	cf	—
Schellwienella sp.	x	x	—	—	—	—	—
Schellwienella	—	x	—	—	—	x —	x ?
Streptorhynchus tenuicostatus Weller	x	—	—	—	—	x —	—
Streptorhynchus n. sp.	—	—	—	—	x	—	—
Orthotetes sp.	—	—	x	—	—	—	—
Chonetes burlingtonensis Weller	—	—	—	—	?	—	x
Chonetes glenparkensis Weller	—	x	—	x	—	x —	—
Chonetes illinoisensis Worthen	—	x	x	x	x	x x	x x
Chonetes logani N. & P.	x	x	x	x	—	—	—
Chonetes missouriensis Weller	x	—	—	—	—	x x	—
Chonetes multicostus Winchell	—	x	—	—	—	x —	—
Chonetes ornatus arkansanus Girty	—	—	—	—	x	—	—
Chonetes n. sp.	—	—	—	—	x	—	—
Productus arcuatus Hall	x	—	—	cf	—	?	—
Productus burlingtonensis Hall	—	—	—	—	—	x —	x x
Productus fernglenensis Weller	x	x	x	x	?	x —	—
Productus newtonensis Moore	—	—	—	—	x	—	—
Productus sampsoni Weller	x	x	x	x	?	x —	—
Productus sedaliensis Weller	x	x	—	—	—	—	—
Productus ovatus Hall	x	x	—	cf	x	x —	—
Productus viminalis White	—	—	—	—	—	x —	x x
Pustula alternata (N. & P.)	—	?	—	—	—	x x	? x
Pustula arctifossa Moore	—	—	—	—	—	x —	—
Pustula concentrica (Hall)	?	x	—	x	?	x —	—
Pustula laevicula Moore	—	x	—	—	—	x —	—
Pustula millespinosa (Girty)	—	—	—	—	—	?	—
Pustula morbilliana (Winchell)	—	x	—	—	—	x —	—
Pustula newarkensis Moore	—	—	—	—	x	—	—

FAUNAL TABLE XLI—Continued.

Formations	Pierson	Sedalia	Fern Glen	St. Joe	Reeds Spring	Lower Burlington	Upper Burlington
<i>Brachiopods—Cont'd</i>							
Pustula n. sp.	x	—	—	—	—	—	—
Rhipidomella burlingtonensis (Hall)	—	x	—	x	—	x x	x x
Rhipidomella diminutiva Rowley	x	x	—	—	—	x	—
Rhipidomella dubia (Hall)	—	—	—	—	—	—	x x
Rhipidomella jerseyensis Weller	—	?	x	x	x	x	—
Rhipidomella tenuicostata Weller	—	—	—	—	x	—	—
Rhipidomella thiemei (White)	—	x	—	—	—	x	—
Schizophoria chouteauensis Weller	—	—	—	—	—	?	—
Schizophoria poststriatula Weller	x	x	x	x	?	x	—
Schizophoria sedaliensis Weller	x	x	—	—	—	?	—
Schizophoria subelliptica W. & W.	—	—	—	x	—	x	—
Schizophoria swallovi (Hall)	—	—	—	—	—	x x	x x
Camarophoria bisinuata (Rowley)	—	—	x	—	x	x x	—
Camarotoechia chouteauensis Weller	—	x	—	x	—	—	—
Camarotoechia elegantula Rowley	—	—	—	—	—	x	—
Camarotoechia tuta (Miller)	—	—	—	—	—	x	—
Pugnoides boonensis (Shumard)	—	—	—	—	—	x	—
Rhynchotetra elongata Weller	x	—	—	—	—	—	—
Rhynchotetra gibbosa (Greger)	—	—	—	—	—	x	—
Rhynchotetra missouriensis Weller	—	—	—	—	—	x	—
Tetracamera subtrigona (M. & W.)	—	—	—	—	?	—	—
Shumardella missouriensis (Shumard)	x	x	—	—	—	x	—
Shumardella obsolens (Hall)	—	x	—	?	—	—	—
Rhynchopora ? cooperensis (Shumard)	?	x	—	—	—	x	—
Rhynchopora persinuata (Winchell)	x	x	x	x	x	x	—
Centronella ? emaciata Rowley	—	—	—	—	—	x	—
Centronelloidea rowleyi (Worthen)	—	x	—	—	—	x	—
Cranaena globosa Weller	—	x	—	—	—	x	x
Cranaena sp.	x	x	—	—	—	—	—
Dielasma burlingtonense (White)	—	?	—	—	—	x	—
Dielasma chouteauense Weller	x	—	—	—	—	x	—
Dielasma fernglenense Weller	x	—	x	—	—	x	—
Dielasma osceolense Weller	—	—	—	—	x	x	—
Cyrtina burlingtonensis Rowley	—	x	x	—	—	x	—
Spiriferina solidirostris White	—	x	—	—	—	x	—
Spiriferina subtexta White	x	x	x	x	x	x x	—
Spiriferina n. sp.	—	—	—	x	—	—	—
Delthyris novamexicana (Miller)	x	x	x	x	—	—	—
Spirifer buehleri Moore	—	x	—	—	x	—	—
Spirifer carinatus Rowley	—	—	—	—	—	* x	—
Spirifer forbesi N. & P.	—	x	—	—	—	x x	—
Spirifer gregeri Weller	—	x	—	—	—	x	—
Spirifer grimesi Hall	—	—	—	—	—	x x	x x
Spirifer imbrex Hall	—	—	—	x	—	x x	—
Spirifer incertus Hall	—	?	—	—	—	x x	? x
Spirifer legrandensis Weller	—	cf	—	—	—	—	—

FAUNAL TABLE XLI—Continued.

Formations	Pierson	Sedalia	Fern Glen	St. Joe	Reeds Spring	Lower Burlington	Upper Burlington
<i>Brachiopods—Cont'd</i>							
<i>Spirifer insculptus</i> Rowley	—	x	—	—	—	* x	—
<i>Spirifer louisianensis</i> Rowley	x	x	—	x	x	x x	—
<i>Spirifer missouriensis</i> Swallow	—	x	—	?	—	x	—
<i>Spirifer mundulus</i> Rowley	—	cf	—	—	—	x	—
<i>Spirifer osagensis</i> Swallow	x	x	—	—	x	x	—
<i>Spirifer piersonensis</i> Moore	x	x	—	—	—	—	—
<i>Spirifer pikensis</i> Rowley	—	—	—	—	—	*	—
<i>Spirifer platynotus</i> Weller	—	x	—	—	—	?	—
<i>Spirifer rowleyi</i> Weller	?	?	x	x	x	x	—
<i>Spirifer shepardi</i> Weller	x	?	—	x	x	x	—
<i>Spirifer vantuyli</i> Moore	—	—	—	—	—	x	—
<i>Spirifer striatiformis</i> Meek	x	—	—	?	—	—	—
<i>Spirifer vernonensis</i> Swallow	—	x	x	x	—	x	—
<i>Brachythyris chouteauensis</i> (Weller)	x	x	x	x	x	x	—
<i>Brachythyris fernglenensis</i> (Weller)	—	?	x	—	—	—	—
<i>Brachythyris suborbicularis</i> (Hall)	—	—	—	?	?	x x	— x
<i>Syringothyris newarkensis</i> Weller	—	—	—	—	—	x	—
<i>Syringothyris typus</i> Winchell	—	—	—	—	—	cf	—
<i>Syringothyris platypieurus</i> Weller	—	—	—	—	—	x	—
<i>Pseudosyrinx keokuk</i> Weller	—	—	—	—	cf	—	—
<i>Pseudosyrinx missouriensis</i> Weller	—	x	—	—	—	x	x
<i>Pseudosyrinx sampsoni</i> (Weller)	—	x	x	x	—	—	—
<i>Spiriferella plena</i> (Hall)	—	—	—	—	—	x	x x
<i>Spiriferella</i> ? <i>schucherti</i> (Rowley)	—	x	—	—	—	x	—
<i>Ambocoelia levicula</i> Rowley	—	x	—	—	—	x	—
<i>Ambocoelia parva</i> Weller	x	x	—	—	—	—	—
<i>Reticularia cooperensis</i> (Swallow)	x	x	—	x	x	x	—
<i>Reticularia pseudolineata</i> (Hall)	—	—	—	—	—	x	— x
<i>Ptychospira sexplicata</i> (W. & W.)	—	x	x	—	x	?	—
<i>Eumetria perstrialis</i> Rowley	—	—	—	—	—	x	—
<i>Eumetria popeana</i> (Swallow)	—	?	—	—	—	—	—
<i>Hustedia circularis</i> (Miller)	—	—	?	—	—	—	—
<i>Hustedia</i> n. sp.	—	—	—	—	—	x	—
<i>Nucleospira barrisi</i> White	—	x	—	—	—	—	—
<i>Nucleospira obesa</i> Rowley	—	—	—	—	—	x	—
<i>Rowleyella fabulites</i> (Rowley)	—	?	—	—	—	?	—
<i>Athyris lamellosa</i> (L'Eveille)	x	x	x	x	x	x x	x x
<i>Cliothyridina glenparkensis</i> Weller	—	?	x	x	x	x	—
<i>Cliothyridina incassata</i> (Hall)	—	—	—	—	—	x x	x x
<i>Cliothyridina obmaxima</i> (McChesney)	—	—	x	?	x	x	— ?
<i>Cliothyridina parvirostris</i> (M. & W.)	—	—	—	—	—	x	x x
<i>Cliothyridina prouti</i> (Swallow)	?	—	x	x	x	—	—
<i>Cliothyridina tenuicostata</i> (Rowley)	?	x	—	x	x	x	— ?
<i>Composita trinuclea</i> (Hall)	—	—	—	—	—	x	—
<i>Pelecypods</i>							
<i>Edmondia jejuna</i> (Winchell)	—	?	—	—	—	—	—

FAUNAL TABLE XLI—Continued.

Formations	Pierson	Sedalia	Fern Glen	St. Joe	Reed Springs	Lower Burlington	Upper Burlington
<i>Pelecypods—Cont'd</i>							
Edmondia	?	—	—	—	?	—	—
Pernopecten cooperensis (Shumard)	x	x	—	—	—	?	—
Aviculopecten fernglenensis Weller	—	—	x	—	—	—	—
Aviculopecten	—	x	—	—	x	x	—
Pterinopecten sedaliensis Miller	x	x	—	—	—	x	—
Lithophagus minutus Weller	—	—	—	—	—	cf	—
Parallelodon sp.	x	—	—	—	—	—	—
Cardiopsis sp.	—	—	—	—	—	x	—
Cypriocardinia imbricata (Rowley)	—	—	—	—	—	x	—
Conocardium	—	—	x	—	—	x	—
<i>Gastropods</i>							
Bellerophon blairi Miller	—	—	—	—	—	?	—
Bellerophon panneus White	—	x	—	—	—	—	—
Pleurotomaria mississippiensis W. & W.	—	x	—	—	—	—	—
Pleurotomaria sp.	—	—	—	—	—	x	—
Strophostylus bivalve (W. & W.)	—	x	—	—	—	—	—
Platyschisma depressa Weller	—	—	—	—	—	cf	—
Straparollus ammon (W. & W.)	—	—	—	—	—	x	—
Straparollus latus (Hall)	—	—	—	—	—	x	—
Straparollus obtusus (Hall)	—	—	—	—	—	x	—
Straparollus	—	x	—	—	—	—	x
Soleniscus sp.	—	x	—	—	—	—	—
Holopea	—	—	—	x	—	x	—
Naticopsis n. sp.	—	—	—	—	—	x	—
Platyceras latum Keyes	—	—	—	—	—	—	x x
Platyceras nasutum Miller	x	x	—	—	—	x	—
Platyceras obliquum Keyes	—	—	—	—	—	x	x x
Platyceras paralum (W. & W.)	—	x	x	x	x	x	x x
Platyceras vomerium (Winchell)	—	x	—	—	—	—	—
Orthonychia cornuformis (Winchell)	—	—	—	—	—	x	—
Orthonychia quincyensis (McChesney)	—	—	—	—	—	—	x
Igoceras capulum (Keyes)	—	—	—	—	—	x	x
Igoceras pabulocrinum (Owen)	—	—	—	—	—	?	x
Igoceras undatum (Winchell)	—	x	—	—	—	—	—
Lepetopsis umbella (Hall)	—	—	—	—	—	—	x
<i>Cephalopods</i>							
Orthoceras	x	—	x	—	—	x	—
Cyrtoceras missouriense Swallow	—	?	—	—	—	—	—
Cyrtoceras sp.	—	—	x	—	—	—	—
Muensteroceras ? osagense Swallow	—	—	—	—	—	x	—
<i>Trilobites</i>							
Phillipsia insignis Winchell	—	—	—	—	—	?	—
Phillipsia sampsoni Vogdes	?	—	—	x	—	x	—
Phillipsia tuberculata M. & W.	—	—	—	—	—	x	—
Phillipsia	—	?	—	—	?	x x	—

FAUNAL TABLE XLI—Continued.

Formations	Pierson	Sedalia	Fern Glen	St. Joe	Reeds Spring	Lower Burlington	Upper Burlington
<i>Trilobites—Cont'd</i>							
Griffithides sedaliensis Vogdes	—	—	—	—	—	x —	— —
Proetus fernglenensis Weller	—	—	x	cf	—	— —	— —
Proetus swallowi Shumard	—	—	—	—	—	—	— —

KEOKUK LIMESTONE

The Keokuk limestone was named by James Hall¹⁷ in 1857 from the town of Keokuk in southeastern Iowa. The formation was defined to include the “Keokuk cherty limestone,” Shell beds and “Lower Archimedes limestone” of Owen³⁶, and overlying geodiferous shale. Recent studies by Van Tuyl⁵⁹ indicate that the fauna of the geode-bearing shale is related more closely to the Warsaw formation, and accordingly it is excluded from the Keokuk.

Lithologic character. The Keokuk formation consists mainly of bluish and gray or buff medium to coarse-grained, more or less crystalline cherty limestone. In general the color is rather distinctly more bluish than that of the Burlington and the beds are commonly less massive. In southeastern Iowa and northeastern Missouri the limestone beds are separated in many cases by thin shale seams but in central and southwestern Missouri the rocks of Keokuk age are mainly massive limestone with little or no shaly material. Chert is abundant in most exposures, especially in the southwestern part of the state, where the formation is lithologically more or less indistinguishable from the Burlington. Stylolites are common and some of them are very large.

Stratigraphic relations. There is no clear evidence of a stratigraphic break either at the base or top of the Keokuk in southeastern Iowa⁵⁹ or northeastern Missouri. In most of southwestern Missouri, however, there is clearly a hiatus representing Upper Burlington time and there was apparently an erosion interval between the time of deposition of the Keokuk and Warsaw beds. The latter is indicated by basal conglomerates consisting mainly of angular chert at the base of the Warsaw and of solution cavities in the Keokuk filled by limestone

and chert fragments cemented in a Warsaw limestone matrix. In southwestern Missouri beds of Keokuk age comprise two members in the middle part of the Boone formation. The Grand Falls chert member, resting disconformably on the early Osage Reeds Spring limestone, is overlain conformably by cherty limestone. These units are very typically developed and are well exposed in the Joplin district.

Distribution and thickness. The Keokuk covers the surface in parts of the Mississippian area of northeastern Missouri but has not been differentiated in mapping. It is known to be present in the vicinity of St. Louis and southward. North of Missouri river in the central part of the state the formation is partly overlapped by the Pennsylvanian, the exposed Osage limestone beds belonging mostly to the Burlington. Good exposures are found in the vicinity of Boonville. Limestone of Keokuk age is widely distributed in southwestern Missouri, much of the rock that has been called Burlington in this region belonging instead to the Keokuk and Warsaw. The thickness of the Keokuk in the type region is 70 feet and it is about the same in the adjoining part of Missouri. It is about 100 to 150 feet in thickness in southwestern Missouri; the Grand Falls chert has an average thickness of 55 feet, the overlying Keokuk limestone about 100 feet.

Stratigraphic sections and faunal character. In eastern Missouri the Keokuk was examined by the writer only in Lincoln county along Cuivre river where both Keokuk and Warsaw rocks appear to be present. At Moscow Mills below the Burlington railroad bridge over Cuivre river there is an exposure of 14 feet of blue fine to medium-grained crystalline, siliceous, rather thin bedded limestone containing numerous dark chert nodules and thin bands. Fossils collected from this limestone indicate Keokuk age.

XLII. Fossils from Keokuk Limestone in Quarry and Ravine at Moscow Mills, Lincoln County. Sec. 4, T. 48 N., R. 1 E.

<i>Coral</i>	<i>Brachiopods</i>
Zaphrentis sp.	Schellwienella sp.
<i>Crinoid</i>	Streptorhynchus sp.
Megistocrinus ? sp.	Orthotetes ? sp.
<i>Bryozoans</i>	Productus setigerus Hall
Fenestella sp. 1, 2, 3, 4	Productus sp.
Archimedes sp.	Pustula alternata (N. & P.)
Cystodictya lineata Ulrich	Rhipidomella dubia (Hall)
Worthenopora spinosa Ulrich	Camarotoechia sp. cf. C. mutata (Hall)

<i>Spiriferina</i> sp.	<i>Lithophagus</i> ? sp.
<i>Spirifer keokuk</i> Hall	<i>Gastropod</i>
<i>Spirifer</i> sp.	<i>Orthonychia pabulocrinus</i> (Owen) ?
<i>Brachythyris suborbicularis</i> (Hall)	<i>Trilobite</i>
<i>Reticularia pseudolineata</i> (Hall)	<i>Griffithides portlocki</i> M. & W. ?
<i>Cliothyridina obmaxima</i> (McChesney) ?	<i>Fish</i>
<i>Composita</i> sp.	Fish teeth
<i>Pelecypods</i>	
<i>Pinna subspatulata</i> Worthen	

At Chain of Rocks, on Cuivre river about 4 miles southwest of Old Monroe, Lincoln county, the following section was measured:

(46.) Section of Keokuk Limestone at Chain of Rocks, Southwest of Old Monroe

Osage group Keokuk limestone	Thickness	
	Feet.	Inches.
6. Limestone, blue to bluish gray, hard, compact, subcrystalline, rather thin-bedded. Contains <i>Archimedes</i> sp. Poorly exposed	10	
5. Limestone, bluish gray, medium-grained, siliceous, cherty, partly covered	6	
4. Shale, buff to bluish, sandy, contains irregular thin lenses of siliceous and cherty limestone	1	
3. Limestone, bluish gray, medium-grained, hard, compact, thin-bedded, cherty, fossiliferous	4	
2. Limestone, light gray, rather coarse-grained, crystalline, massive, fossiliferous	8 to 12	
1. Limestone, like 3 but thin-bedded and cherty, some of the beds slightly shaly, contains a few fossils	4	6

Collections of fossils obtained from beds 1-2, and 3 are reported in the following list. The relative importance of bryozoans and the presence of several characteristic species indicate the Keokuk age of the beds.

XLIII. Fossils from the Keokuk Limestone at Chain of Rocks, Cuivre River, Southwest of Old Monroe

Beds.	1-2	3
<i>Corals</i>		
<i>Zaphrentis</i> sp.	x	—
<i>Triplophyllum dalei</i> (E. & H.)	x	—
<i>Bryozoans</i>		
<i>Fenestella exigua</i> Ulrich ?	x	—
<i>Fenestella multispinosa</i> Ulrich	x	x
<i>Fenestella serratula</i> Ulrich	?	x
<i>Fenestella serratula</i> var. <i>quadrata</i> Cumings	—	x
<i>Fenestella compressa</i> var. <i>nododorsalis</i> Ulrich	x	—
<i>Fenestella cingulata</i> Ulrich ?	x	—
<i>Archimedes owenianus</i> Hall	x	—
<i>Cystodictya lineata</i> Ulrich	x	x
<i>Glyptopora</i> sp.	—	x

FAUNAL TABLE XLIII—Continued.

Beds.	1-2	3
<i>Brachiopods</i>		
Schellwienella ? sp.	—	x
Orthotetes keokuk (Hall)	x	x
Chonetes illinoisensis Worthen.	x	—
Productus setigerus Hall.	x	x
Productus ovatus Hall.	—	x
Pustula alternata (N. & P.)	x	x
Rhipidomella dubia (Hall)	—	x
Cranaena sp.	x	—
Spirifer keokuk Hall.	—	x
Spirifer tenuicostatus Hall.	—	x
Spirifer sp.	—	x
Brachythyris suborbicularis (Hall)	x	x
Reticularia pseudolineata (Hall)	—	x
Athyris lamellosa (L'Eveille)	—	x
<i>Trilobites</i>		
Griffithides portlocki M. & W.	x	—
Phillipsia sp.	x	—

Keokuk limestone is well exposed in the Missouri river bluffs at Boonville. Detailed stratigraphic study in this area will doubtless give a complete section from the Burlington through the Warsaw which overlies the Keokuk here, but the writer's observations are insufficient to indicate more than the presence of the formations mentioned. A section, measured in the Missouri river bluff at the east edge of Boonville, shows the character of the beds here.

(47.) Section of Keokuk Limestone at the East Edge of Boonville

	Thickness Feet, Inches.	
7. Loess.	10	
Osage group		
Keokuk limestone		
6. Limestone, gray to buff, thin-bedded, cherty, fine-grained, subcrystalline.	6	
5. Limestone, light buff, medium-grained, beds 6 to 10 inches thick, breaks along nearly smooth vertical joint planes, non-cherty.	4	9
4. Limestone, blue, weathers light buff, medium-grained, in beds 6 to 12 inches, cherty in lower and upper part, stylolites present. <i>Chonetes illinoisensis</i> Worthen abundant in zone 3 ½ feet above base.	9	
3. Limestone, blue, medium to coarse-grained, massive, non-cherty, stylolites common.	4	4
2. Limestone, blue and buff, medium-grained, contains abundant chert in thin irregular bands and nodules up to 10 inches in thickness.	2	6

	Thickness Feet. Inches.
1. Limestone, blue, medium to coarse-grained, crystalline, massive, non-cherty, stylolites common. Contains <i>Orthotetes keokuk</i> Hall, <i>Triplophyllum dalei</i> (E. & H.) <i>Spirifer</i> sp. and numerous fish teeth. Exposed.....	4

A collection of fossils from Bed 4 contains the following species:

XLIV. Fossils from Bed 4, Keokuk Limestone at East Edge of Boonville

<i>Coral</i>	<i>Rhipidomella dubia</i> (Hall)
<i>Triplophyllum dalei</i> (E. & H.)	<i>Spirifer rostellatus</i> Hall
<i>Bryozoan</i>	<i>Spirifer keokuk</i> Hall.
<i>Rhombopora</i> sp.	<i>Spirifer</i> sp.
<i>Brachiopods</i>	<i>Brachythyris suborbicularis</i> (Hall)
<i>Orthotetes keokuk</i> (Hall)	<i>Reticularia pseudolineata</i> (Hall)
<i>Chonetes illinoisensis</i> Worthen	<i>Composita globosa</i> Weller
<i>Productus setigerus</i> Hall ?	<i>Trilobite</i>
<i>Productus</i> sp.	<i>Griffithides portlocki</i> M. & W.
<i>Pustula alternata</i> (N. & P.)	

One mile east of Boonville slightly lower beds are exposed in a cut on the Missouri Pacific Railroad. The limestone here is massive and collection of fossils is rather difficult. The character of the beds is indicated in the following section:

(48.) Section of Keokuk Limestone One Mile East of Boonville

	Thickness Feet. Inches.
Osage group	
Keokuk limestone	
3. Limestone, blue, medium-grained, massive, chert at base and near top. Contains <i>Orthotetes keokuk</i> Hall, <i>Reticularia pseudolineata</i> (Hall), <i>Productus setigerus</i> Hall and several undetermined species of crinoids.....	8
2. Limestone, light blue, medium-grained, massive, non-cherty, contains large stylolites.....	6
1. Limestone, blue to buff, cherty, medium-grained, massive. <i>Orthotetes keokuk</i> Hall very abundant. Exposed.....	8

Fossils collected from Beds 1 and 2 are reported in the following list:

XLV. Fossils from Keokuk Limestone One Mile East of Boonville

Beds.	1	2
<i>Corals</i>		
<i>Zaphrentis</i> sp. cf. <i>C. varsoviensis</i> (Worthen).....	—	x
<i>Zaphrentis</i> sp.....	—	x
<i>Triplophyllum dalei</i> (E. & H.).....	—	x
<i>Amplexus fragilis</i> White & St. John.....	—	x

FAUNAL TABLE XLV—Continued.

Beds.	1	2
<i>Bryozoans</i>		
Rhombopora varians Ulrich ?	—	x
Worthenopora spatulata Ulrich ?	—	x
<i>Brachiopods</i>		
Orthotetes keokuk (Hall)	x	x
Chonetes illinoisensis Worthen	—	x
Productus setigerus Hall	—	x
Productus sp. cf. P. magnus Hall	—	x
Productus sp. cf. P. wortheni Hall	—	x
Productus sp.	x	—
Pustula biseriata (Hall)	—	x
Pustula sp.	—	x
Rhipidomella dubia (Hall)	x	x
Rhipidomella sp.	x	—
Tetracamera subtrigona (M. & W.)	x	—
Cranaena globosa Weller ?	x	—
Spirifer tenuicostatus Hall	—	x
Spirifer keokuk Hall	—	x
Brachythyris suborbicularis (Hall)	—	x
Syringothyris sp.	x	—
Reticularia pseudolineata (Hall)	—	x
Athyris lamellosa (L'Eveille)	—	x
Cliothyridina obmaxima (McChesney)	—	x
Cliothyridina parvirostra (M. & W.)	—	x
Composita globosa Weller	?	x

Near the base of Bed 2 at a point $1\frac{1}{2}$ miles east of Boonville the following collection was made:

XLVI. Fossils from Keokuk Limestone, $1\frac{1}{2}$ Miles East of Boonville

Coral

Triphophyllum dalei (E. & H.)

Bryozoans

Fistulipora sp.

Leioclema punctatum (Hall) ?

Fenestella tenax Ulrich ?

Fenestella multispinosa Ulrich ?

Fenestella serratula Ulrich

Fenestella triserialis Ulrich ?

Fenestella sp. 1, 2, 3

Polypora varsoviensis Prout ?

Polypora simulatrix Ulrich

Polypora sp. 1, 2

Hemitrypa pateriformis Ulrich

Hemitrypa sp.

Stictoporella basalis Ulrich

Cyclopora sp. 1, 2

Worthenopora spatulata Ulrich

Brachiopods

Chonetes illinoisensis Worthen

Productus mesialis Hall

Productus wortheni Hall

Productus sp.

Productus sp.

Pustula alternata (N. & P.)

Rhipidomella dubia (Hall)

Spirifer sp.

Spirifer sp.

Syringothyris ? sp.

Reticularia pseudolineata (Hall)

Composita globosa Weller

Pelecypod

Aviculopecten niotensis Worthen ?

Gastropods

Platyceras paralium W. & W.

Platyceras sp.

Orthonychia sp.

One mile north of Warsaw loose fragments of limestone containing a Keokuk or Warsaw bryozoan assemblage were seen but the rock was not found in place. The following species were distinguished:

XLVII. Keokuk (?) Bryozoans in Limestone near Warsaw, Benton County

<i>Fenestella tenax</i> Ulrich	<i>Archimedes owenanus</i> Hall
<i>Fenestella compressa</i> Ulrich	<i>Rhombopora attenuata</i> Ulrich
<i>Fenestella compressa</i> var. <i>nododorsalis</i> Ulrich	<i>Rhombopora varians</i> Ulrich
<i>Fenestella serratula</i> Ulrich	<i>Cystodictya nitida</i> Ulrich
<i>Fenestella regalis</i> Ulrich	<i>Cystodictya lineata</i> Ulrich
<i>Polypora retrorsa</i> Ulrich	<i>Cyclopore</i> sp.

In southwestern Missouri limestone and chert assigned to the Keokuk stage occur above Burlington beds and underlie a thin widespread oolitic limestone, the Short Creek oolite. In parts of the region, especially near Joplin, a prominent member, the Grand Falls chert, consisting of a light colored, dense chert 15 to 60 feet in thickness, occurs at the base of the Keokuk portion of the Boone formation. It is described in some detail in the Joplin folio⁴⁹ and fossils collected from it show that the member is of Keokuk age. The chert rests disconformably on the early Osage Reeds Spring limestone member of the Boone. The more or less cherty, medium to coarse-grained limestone, about 100 feet thick, occurs next above the Grand Falls. Evidence of a stratigraphic break, probably of no great time value, is found at several places at the top of this division.

A section at the Marblehead lime quarry, 1 mile north of Sarcoxie in Jasper county, shows the upper part of the cherty limestone and the Short Creek oolite. In part of the quarry a large depression is filled with irregular limestone and cherty debris, cemented together by shaly and oolitic limestone containing *Rhipidomella dubia* (Hall), *Camarotoechia mutata* (Hall), *Tetracamera subcuneata* (Hall), *Allorhynchus* ? sp., and *Composita* sp. cf. *C. globosa* Weller, which are apparently fossils of the matrix and not rolled specimens derived from older rocks. The fossils are common in the Short Creek (Warsaw) oolite. At the top of the fill evenly-bedded oolitic and crystalline limestone of the Warsaw is found. The relations indicate an interval of erosion between Keokuk and Warsaw time.

(49.) Section at Marblehead Lime Quarry on West Bluff of Spring River, 1 Mile North of Sarcoxie, Jasper County

	Thickness Feet. Inches.	
Osage group		
Boone formation		
Warsaw limestone member		
5. Limestone, light bluish gray, medium to coarse-grained, crystalline, crinoidal, very massive, contains stylolites, fossiliferous.	5	
Short Creek oolite member		
4. Limestone, white, oolitic, massive, lower part somewhat coarser, in upper part oolites are numerous but are embedded in a hard crystalline matrix, weathers along joints oblique to bedding. Fossils not abundant or well preserved	7	6
<i>Disconformity</i>		
Keokuk limestone member		
3. Limestone, bluish gray, medium- to coarse-grained, very massive, chert bands 6 to 18 inches in thickness 4 to 7 feet below top, stylolites present.	15	
2. Chert and limestone interbedded, chert predominating. The chert is irregular, grading into and inclosing fragments of limestone.	2	4
1. Limestone like 3, beds with fine and coarse texture interbedded and intergrading, in part crinoidal, stylolites present, non-cherty. Exposed	14	

XLVIII. Fossils from the Keokuk Limestone at Marblehead Lime Quarry North of Sarcoxie

Beds.	1	3
<i>Corals</i>		
Zaphrentis sp. cf. Z. varsoviensis Worthen	x	—
Zaphrentis sp.	x	—
Amplexus fragilis White & St. John	x	x
<i>Bryozoans</i>		
Fenestella serratula Ulrich ?	x	—
Fenestella sp.	x	—
Polypora maccoyana Ulrich	—	x
Rhombopora attenuata Ulrich	x	—
Cystodictya lineata Ulrich	x	—
Cystodictya sp.	—	x
Glyptopora sp.	x	—
<i>Brachiopods</i>		
Orthotetes keokuk (Hall)	x	x
Chonetes illinoisensis Worthen	x	x
Productus ovatus Hall	x	x
Productus setigerus Hall	?	x
Productus magnus M. & W.	x	—
Productus mesialis Hall	—	x
Productus crawfordsvillensis Weller ?	—	x
Productus n. sp.	x	—
Productus sp.	x	—
Productus sp.	x	—

FAUNAL TABLE XLVIII—Continued.

Beds.	1	3
<i>Brachiopods—Cont'd</i>		
Pustula biseriata (Hall).....	x	—
Pustula alternata (N. & P.).....	x	x
Pustula sp.....	x	—
Rhipidomella dubia (Hall).....	x	x
Camarotoechia mutata (Hall) ?.....	x	—
Camarotoechia sp.....	—	x
Tetracamera subtrigona (M. & W.).....	—	x
Dielasma sp.....	—	x
Spiriferina sp.....	x	—
Spirifer rostellatus Hall.....	x	—
Spirifer keokuk Hall.....	x	—
Spirifer logani Hall.....	x	—
Spirifer sp.....	—	x
Brachythyris suborbicularis (Hall).....	—	x
Pseudosyrinx keokuk Weller.....	x	?
Reticularia pseudolineata (Hall) ?.....	x	—
Cliothyridina obmaxima (McChesney).....	x	x
Cliothyridina parvirostris (M. & W.).....	—	x
Composita globosa Weller.....	—	x
<i>Pelecypod</i>		
Myalina keokuk Worthen.....	x	—
<i>Gastropods</i>		
Platyceras sp.....	—	x
Platyceras sp.....	x	—
<i>Trilobites</i>		
Griffithides bufo M. & W.....	x	—
Griffithides portlocki M. & W. ?.....	x	x
Griffithides ? sp.....	x	—
<i>Fish</i>		
Fish teeth.....	x	—

Near Joplin there are many exposures of the Keokuk; the following section showing about 40 feet of beds beneath the Short Creek oolite is typical:

(50.) Section in Old Quarry on Opossum Hollow, Southeast Quarter of Northeast Quarter, Section 33, T. 28 N., R. 33 W., Near Joplin

	Thickness Feet. Inches.
12. Soil, red clay and residual chert	
Osage group	
Boone formation	
Warsaw limestone member	
11. Chert, hard, irregularly nodular.....	6
Short Creek oolite member	
10. Limestone, dark gray weathering white, oolitic, the oolites being embedded in a rather argillaceous hard	

		Thickness	
		Feet.	Inches.
	limestone; contains a few fossils including <i>Orthotetes</i> sp. and <i>Rhipidomella dubia</i> (Hall).....	4	
Keokuk limestone member			
9.	Limestone, light gray, medium-grained, subcrystalline, contains little crinoidal material.....	2	
8.	Limestone and chert in thin alternating bands, the limestone light bluish gray, fine to moderately coarse-grained and crinoidal; the chert, bluish, flinty, grades into dense siliceous limestone.....	9	
7.	Limestone, bluish gray, medium- to coarse-grained, massive, contains chert in nodules and bands at intervals of 1-2 feet.....	9	6
6.	Chert and limestone in rather thin alternating bands, the chert predominating; limestone lithologically resembles bed 7.....	2	
5.	Limestone like 7, contains chert in nodules at zones 2, 3, 5 and 7.5 feet above base, stylolites common, fossiliferous, containing especially numerous <i>Orthotetes keokuk</i> Hall.....	8	4
4.	Limestone and chert interbedded, beds about 6 inches in average thickness (exposed near old lime kiln).....	6	
3.	Chert, white, massive, flinty.....	1	6
2.	Limestone, light bluish, medium-grained, crinoidal, a single massive ledge.....	1	
1.	Chert like 3. Exposed.....	2	

XLIX. Fossils from Keokuk Limestone in Quarry on Opossum Hollow, Near Joplin

Beds	5	6
<i>Corals</i>		
<i>Zaphrentis</i> sp. cf. <i>Z. varsoviensis</i> (Worthen).....	—	x
<i>Zaphrentis</i> sp.....	—	x
<i>Triplophyllum dalei</i> (E. & H.).....	?	x
<i>Amplexus fragilis</i> White & St. John.....	—	x
<i>Bryozoans</i>		
<i>Tabulipora</i> sp.....	—	x
<i>Fenestella multispinosa</i> Ulrich ?.....	—	x
<i>Fenestella</i> sp.....	—	x
<i>Fenestella</i> sp.....	x	—
<i>Cystodictya lineata</i> Ulrich.....	—	x
<i>Brachiopods</i>		
<i>Schellwienella</i> sp.....	x	—
<i>Orthotetes keokuk</i> (Hall).....	x	x
<i>Chonetes illinoisensis</i> Worthen.....	x	—
<i>Productus wortheni</i> Hall.....	x	x
<i>Productus setigerus</i> Hall.....	—	x
<i>Productus</i> sp.....	—	x
<i>Productus</i> sp.....	—	x
<i>Pustula alternata</i> (N. & P.).....	x	x
<i>Rhipidomella dubia</i> (Hall).....	x	—
<i>Rhipidomella</i> sp. cf. <i>R. burlingtonensis</i> (Hall).....	x	—
<i>Schizophoria swallowi</i> (Hall) ?.....	x	—
<i>Camarotoechia mutata</i> (Hall).....	—	x
<i>Cranaena globosa</i> Weller.....	x	—

FAUNAL TABLE XLIX—Continued.

Beds.	5	6
<i>Brachiopods—Cont'd</i>		
<i>Dielasma</i> n. sp.	x	—
<i>Spiriferina</i> sp.	x	x
<i>Spirifer tenuicostatus</i> Hall.	x	—
<i>Spirifer logani</i> Hall.	x	—
<i>Spirifer keokuk</i> Hall.	x	—
<i>Spirifer</i> sp.	—	x
<i>Brachythyris suborbicularis</i> (Hall).	x	—
<i>Reticularia pseudolineata</i> (Hall).	x	x
<i>Pelecypod</i>		
<i>Cypricardella</i> sp.	—	x
<i>Gastropods</i>		
<i>Straparollus</i> sp.	—	x
<i>Platyceras paralium</i> W. & W.	—	x
<i>Platyceras</i> sp.	—	x
<i>Platyceras</i> sp.	x	—
<i>Triolobites</i>		
<i>Griffithides portlocki</i> M. & W.	—	x
<i>Griffithides</i> ? sp.	x	—

A short distance up stream, approximately 100 feet from the trestle of the Missouri, Kansas & Texas Railroad, 11 feet of dark bluish subcrystalline limestone with interbedded chert, are exposed. These beds belong a short but undetermined distance below the lowermost strata exposed in the quarry section. The following fossils were collected:

L. Fossils from Keokuk Limestone Near Missouri, Kansas & Texas Railroad Trestle in Opossum Hollow

<i>Bryozoans</i>	<i>Tetracamera subtrigona</i> (M. & W.)
<i>Fenestella</i> sp. 1, 2, 3, 4	<i>Cranaena globosa</i> Weller
<i>Hemitrypa</i> sp.	<i>Spiriferina</i> sp.
<i>Worthenopora spinosa</i> Ulrich	<i>Spirifer rostellatus</i> Hall
<i>Brachiopods</i>	<i>Spirifer</i> sp.
<i>Orthotetes keokuk</i> (Hall)	<i>Athyris lamellosa</i> (L'Eveille)
<i>Productus setigerus</i> Hall	<i>Cliothyridina parvirostra</i> (M. & W.) ?
<i>Pustula alternata</i> (N. & P.)	<i>Reticularia pseudolineata</i> (Hall)
<i>Rhipidomella dubia</i> (Hall)	

From the upper part of the Keokuk limestone on Shoal Creek in section 29, T. 27 N., R. 33 W., the following collection was obtained:

LI. Fossils from Keokuk Limestone on Shoal Creek, Sec. 29, T. 27 N., R. 33 W.

Corals

Zaphrentis sp.
Triplophyllum dalei (E. & H.)
Amplexus fragilis White & St. John
Amplexus sp.

Bryozoans

Fenestella sp.
Fenestella sp.
Polypora sp.
Hemitrypa pateriformis Ulrich
Hemitrypa sp.
Cystodictya lineata Ulrich

Brachiopods

Orthotetes keokuk (Hall)
Chonetes illinoisensis Worthen
Productus wortheni Hall

Productus setigerus Hall
Productus ovatus Hall
Productus sp.
Rhipidomella dubia (Hall)
Camarotoechia mutata (Hall)
Dielasma sp.
Girtyella ? sp.
Spirifer logani Hall
Spirifer rostellatus Hall
Brachythyris suborbicularis (Hall)
Pseudosyrinx keokuk Weller
Reticularia pseudolineata (Hall)
Eumetria veneuiliana (Hall)
Cliothyridina ? sp.
Composita globosa Weller ?

A collection from similar limestone on the Joplin-Neosho road south of Tiptonford contains a slightly larger number of species.

LII. Fossils from Keokuk Limestone on Joplin-Neosho Road South of Tiptonford, Newton County

Corals

Zaphrentis sp.
Amplexus fragilis White & St. John

Crinoid

Platycrinus sp.

Bryozoans

Fenestella serratula Ulrich
Fenestella regalis Ulrich
Fenestella compressa Ulrich
Fenestella compressa var. *elongata* Cumings
Fenestella triserialis Ulrich
Fenestella exigua Ulrich
Fenestella sp.
Rhombopora varians Ulrich ?
Phractopora trifolia (Ulrich)
Cystodictya lineata Ulrich

Brachiopods

Orthotetes keokuk (Hall)
Chonetes illinoisensis Worthen
Productus setigerus Hall
Productus mesialis Hall
Productus sp.
Productus sp.
Pustula alternata (N. & P.)
Pustula sp.

Rhipidomella dubia (Hall)
Rhipidomella burlingtonensis (Hall) ?
Rhipidomella sp.
Schizophoria sp. cf. *S. chouteauensis* Weller
Camarotoechia mutata (Hall)
Dielasma sp.
Cyrtina sp.
Spiriferina sp.
Spirifer keokuk Hall
Spirifer logani Hall ?
Spirifer tenuicostatus Hall
Spirifer rostellatus Hall
Spirifer sp.
Spirifer sp.
Syringothyris ? sp.
Reticularia pseudolineata (Hall)
Cliothyridina parvirostra (M. & W.)
Composita globosa Weller ?

Pelecypods

Cypricardella sp.
Aviculopecten sp.

Gastropods

Platyceras paraliun W. & W.
Orthonychia pabulocrinus (Owen) ?

The Keokuk limestone is found at several places in the vicinity of Neosho, Newton county, and though the character

of the rock is commonly somewhat finer grained and more compact than farther north, the fauna, as shown by collections on Shoal Creek northwest of the mills, shows typical Keokuk characteristics. A section measured in and near an old quarry on the east side of Shoal Creek just northwest of Neosho describes the beds seen in this region.

(51.) Section at Old Quarry on Shoal Creek, Northwest of Neosho, Newton County

		Thickness	
		Feet.	Inches.
Covered to top of hill		15	
Osage group			
Boone formation			
Short Creek oolite member			
2. Limestone, gray, oolitic, massive, contains typical fossils.		4	
Keokuk limestone member			
1. Limestone, bluish, medium-grained, in part crinoidal, massive, interbedded with fine-grained compact very hard blue limestone, chert in nodules and bands. Fossiliferous, <i>Worthenopora spinosa</i> Ulrich, <i>Spirifer keokuk</i> Hall and other fossils range at least 50 feet below top of this division. <i>Orthotetes keokuk</i> Hall occurs in large numbers. Exposed.....		60	

A collection of fossils at this place from Bed 1, mainly from a zone about 26 feet below the Short Creek oolite, is recorded in the following list with collections from localities nearby:

LIII. Fossils from the Keokuk Limestone Near Neosho, Newton County

Localities*	1	2	3
<i>Corals</i>			
Zaphrentis sp. cf. <i>Z. varsoviensis</i> Worthen.....	—	x	—
Zaphrentis sp.	x	x	x
Triplophyllum dalei (E. & H.).....	—	—	x
Amplexus fragilis White & St. John.....	x	—	x
<i>Bryozoans</i>			
Leioclema sp.	—	—	x
Fenestella serratula Ulrich.....	x	—	—
Fenestella limitaris Ulrich ?.....	—	x	—
Fenestella multispinosa Ulrich.....	—	x	—
Fenestella tenax Ulrich ?.....	—	—	x
Fenestella sp.....	—	x	x
Polypora sp.....	—	x	—
Taeniodictya ramulosa Ulrich ?.....	x	—	—
Cystodictya lineata Ulrich.....	—	x	—
Glyptopora sp.....	—	x	—
Cyclopora sp.....	—	x	—
Worthenopora spinosa Ulrich.....	x	x	—

FAUNAL TABLE LIII—Continued.

Localities*	1	2	3
<i>Brachiopods</i>			
Orthotetes keokuk (Hall)	x	x	x
Orthotetes n. sp.	x	—	—
Chonetes illinoisensis Worthen	x	x	x
Productus ovatus Hall	x	x	—
Productus setigerus Hall	?	x	—
Productus wortheni Hall	—	x	—
Productus sp.	x	x	x
Productus sp.	x	x	—
Pustula alternata (N. & P.)	x	x	x
Pustula n. sp.	x	—	—
Rhipidomella dubia (Hall)	?	x	?
Camarotoechia mutata (Hall)	x	x	?
Tetracamera subcuneata (Hall)	x	—	—
Cranaena sp.	x	—	—
Dielasma sp.	x	x	x
Spiriferina sp.	x	x	—
Spirifer keokuk Hall	x	x	—
Spirifer logani Hall	—	—	x
Spirifer tenuicostatus	—	—	x
Spirifer sp.	—	x	x
Brachythyris suborbicularis (Hall)	—	x	—
Pseudosyrinx keokuk Weller ?	x	—	—
Reticularia pseudolineata (Hall)	x	x	x
Ptychospira sp.	—	x	—
Cliothyridina obmaxima (McChesney)	x	—	—
<i>Gastropods</i>			
Platyceras paralum W. & W.	x	—	—
Platyceras sp.	—	—	x
<i>Trilobites</i>			
Griffithides portlocki (M. & W.) ?	x	x	—
Griffithides ? sp.	—	—	x

*Localities: 1, Old quarry on Shoal Creek northwest of Neosho; 2, Quarry near Neosho mills; 3, Old quarry $\frac{1}{2}$ mile north of Neosho, 12 feet of beds exposed.

About three-fourths of a mile southeast of the village of Splitlog in northwestern McDonald county, an exposure of medium-grained bluish limestone was examined, the following collection indicating a horizon high in the Keokuk:

LIV. Fossils from Keokuk Limestone Near Splitlog, McDonald County

Corals

Zaphrentis sp.
 Triplophyllum dalei (E. & H.) ?
 Amplexus fragilis White & St. John

Bryozoans

Leioclema sp.
 Fenestella multispinosa Ulrich
 Fenestella serratula Ulrich

Fenestella compressa var. elongata	Camarotoechia mutata (Hall)
Cummings ?	Tetracamera subtrigona (M. & W.)
Fenestella sp. 1, 2, 3	Dielasma sp.
Polypora simulatrix Ulrich ?	Cyrtina sp.
Polypora sp. 1, 2	Spiriferina sp.
Pinnatopora sp.	Spirifer tenuicostatus Hall
Rhombopora varians Ulrich	Spirifer logani Hall
Cystodictya sp.	Spirifer keokuk Hall
Glyptopora keyserlingi Prout	Brachythyris suborbicularis (Hall)
<i>Brachiopods</i>	Reticularia pseudolineata (Hall)
Streptorhynchus sp.	Eumetria verneuilliana (Hall)
Orthotetes keokuk Hall	Cliothyridina parvirostra (M. & W.)
Chonetes illinoisensis Worthen	Cliothyridina obmaxima (McChesney)
Chonetes sp.	<i>Gastropods</i>
Productus wortheni Hall	Platyceras paralum W. & W.
Productus setigerus Hall ?	Platyceras sp.
Pustula alternata (N. & P.)	<i>Trilobite</i>
Pustula biseriata (Hall)	Griffithides portlocki M. & W. ?
Rhipidomella sp.	

East of Seligman, southwestern Barry county, Boone limestone and chert are well exposed in several cuts on the Missouri and Northern Arkansas Railroad. A typical section from this area is as follows:

(52.) Section of Keokuk Limestone on the Missouri & Northern Arkansas Railroad
East of Seligman

	Thickness Feet. Inches.
Residual clay and chert	
Osage group	
Boone formation	
Keokuk limestone member	
2. Limestone, light blue weathering buff, very massive, chert at horizons 2 to 6 inches apart, medium to coarse-grained, non-crinodial and very crinoidal, fossils few. . .	26
1. Chert, white to yellowish or brown, bedding very irregular, some of the beds seem to have slumped slightly together. At horizons 2 to 3 feet apart are remnants of hard, blue, fine to medium-grained compact limestone, but there are no continuous limestone beds. Exposed. . .	30
Covered.	

LV. Fossils from Keokuk Limestone East of Seligman

<i>Corals</i>	Productus ovatus Hall
Zaphrentis sp. 1, 2	Pustula alternata (N. & P.) ?
<i>Bryozoans</i>	Rhipidomella dubia (Hall) ?
Fistulipora ? sp.	Schizophoria swallowi Hall
Fenestella sp.	Camarotoechia tuta (Miller)
Hemitrypa sp.	Tetracamera subtrigona (M. & W.)
Cystodictya sp.	Dielasma sp.
<i>Brachiopods</i>	Dielasma sp.
Orthotetes keokuk (Hall)	Delthyris similis Weller
Chonetes illinoisensis Worthen	Spirifer rostellatus Hall
Productus wortheni Hall ?	Spirifer tenuicostatus Hall

Spirifer logani Hall ?	<i>Gastropods</i>
Spirifer sp.	Platyceras paralum W. & W.
Pseudosyrinx keokuk Weller ?	Platyceras sp.
Reticularia pseudolineata (Hall)	Orthonychia sp.
Athyris lamellosa (L'Eveille)	<i>Trilobites</i>
<i>Pelecypod</i>	Griffithides bufo (M. & W.) ?
Aviculopecten sp.	Phillipsia ? sp. 1, 2

At Monett, near the north line of Barry county, a good exposure of massive Osage limestone, apparently referable to the Keokuk was examined. It was difficult to collect fossils and faunal evidence is incomplete. The section is as follows:

(53.) Section of Keokuk Limestone, One-fourth Mile South of Monett, Barry County

		Thickness	
		Feet.	Inches.
Osage group			
Boone formation			
Keokuk limestone member			
4.	Limestone, light bluish gray, massive, fine- to medium-grained, crystalline, contains crinoid fragments, very even texture, cherty near top.....	12	
3.	Limestone like 4 but thinner bedded, mostly non-cherty but in places contains large chert nodules. <i>Chonetes illinoisensis</i> Worthen and <i>Orthotetes keokuk</i> (Hall) very abundant; <i>Productus wortheni</i> Hall, <i>Productus</i> sp. <i>Pustula alternata</i> (N. & P), <i>Dielasma</i> sp. <i>Spirifer grimesi</i> Hall ?, and <i>Platyceras</i> sp. present.		
2.	Limestone, light blue, massive, medium-grained, crystalline, mostly non-cherty but in places contains scattered chert lenses and discontinuous bands. At one place many angular fragments of more or less weathered and broken chert are promiscuously strewn in the limestone, suggesting possible interruption in sedimentation. Contains <i>Chonetes illinoisensis</i> Worthen, <i>Spirifer grimesi</i> and <i>Productus</i> sp.....	4	
1.	Limestone, light blue, medium to coarse-grained, massive, very cherty; contains <i>Chonetes illinoisensis</i> Worthen and <i>Spirifer</i> sp. Exposed.....	13	

At Peirce City in Lawrence county coarse-grained crinoidal limestone with Keokuk fossils is observed.

(54.) Section of Keokuk Limestone in Lime Quarry at Peirce City, Lawrence County

		Thickness	
		Feet.	Inches.
Osage group			
Boone formation			
Keokuk limestone member			
4.	Red clay with abundant chert fragments.....	12	
3.	Limestone, light blue, medium- to coarse-grained, in interbanded layers, crystalline, crinoidal, very massive, chert in nodules but not distributed in distinct layers stylolites present.....	5 to 7	
2.	Limestone similar to 3 but very cherty.....	8	9
1.	Limestone like 3, uneven but persistent alternation of coarse and finer-grained rock prominent, a few nodules of chert occur 12 and 15 feet from top, fossiliferous. Exposed.....	19	3

LVI. Fossils from the Keokuk Limestone at Lime Quarry, Peirce City

Corals

- Zaphrentis sp. 1, 2
- Triplophyllum dalei (E. & H.)
- Amplexus sp. cf. A. blairi Miller
- Homalophyllum calceolum White ?

Crinoid

- Uperocrinus ? sp.

Bryozoans

- Leioclema sp.
- Fenestella sp.
- Cystodictya lineata Ulrich
- Cystodictya lineata var. major Ulrich

Brachiopods

- Orthotetes keokuk (Hall)
- Chonetes illinoisensis Worthen
- Productus setigerus Hall
- Productus sp. cf. P. magnus M. & W.
- Pustula alternata (N. & P.)
- Pustula sp.
- Rhipidomella sp. cf. R. dubia (Hall)
- Rhipidomella sp.
- Schizophoria swallowi Hall
- Tetracamera subtrigona (M. & W.)
- Dielasma chouteauense Weller ?

Dielasma sinuatum Weller

Dielasma sp.

Spiriferina sp.

Spirifer rostellatus Hall

Spirifer logani Hall

Spirifer keokuk Hall

Spirifer tenuicostatus Hall ?

Syringothyris sp.

Syringothyris ? sp.

Pseudosyrinx keokuk Weller

Spiriferella plena (Hall)

Spiriferella neglecta (Hall)

Spiriferella sp.

Reticularia pseudolineata (Hall)

Cliothyridina obmaxima (McChesney)

Pelecypod

Aviculopecten sp.

Gastropods

Platyceras paraliu W. & W.

Platyceras sp.

Lepetopsis capulus (Hall)

Trilobite

Phillipsia ? sp.

Along a small creek about 1 mile northwest of Mt. Vernon, Lawrence county, bluish gray, crystalline, crinoidal limestone is exposed in an old quarry. The lower 7½ feet of beds seen contain nodules and thin bands of dense white chert; the upper 15 feet are lithologically similar except for somewhat more massive bedding and lesser abundance of chert. Locally there is a prominent horizon of broken partly weathered chert embedded in limestone at the base of the upper division. There is no evidence that this deposit was made subsequent to overlying limestone, as appears to be the case in certain instances where solution cavities in the limestone have been filled with broken chert and limestone, but rather this broken chert zone is an integral part of the stratigraphic sequence. It probably represents a disconformity between the lower limestone (Burlington) which contains abundant *Spirifer grimesi* Hall, *Rhipidomella burlingtonensis* (Hall), and *Chonetes illinoisensis* Worthen, and the upper beds (Keokuk) in which *Spirifer logani* Hall, *Orthotetes keokuk* Hall, *S. rostellatus* Hall and *Rhipidomella dubia* (Hall) are common fossils. The following list shows species obtained in a collection at the quarry northwest of Mt. Vernon, but exact data on their stratigraphic distribution in the section are lacking:

LVII. Fossils from the Keokuk and Upper Burlington Limestones, Northwest of Mt. Vernon, Lawrence County

Corals

- Zaphrentis* sp.
Triplophyllum dalei (E. & H.)
Homalophyllum calceolum White

Crinoid

- Macrocrinus verneuillianus* (Shumard) ?

Bryozoans

- Tabulipora* ? sp.
Fenestella sp. 1, 2
Cystodictya lineata Ulrich

Brachiopods

- Orthis keokuk* (Hall)
Chonetes illinoisensis Worthen
Chonetes sp. cf. *C. glenparkensis* Weller
Productus setigerus Hall
Productus wortheni Hall
Pustula alternata (N. & P.)
Rhipidomella burlingtonensis Hall
Rhipidomella dubia (Hall)
Schizophoria swallowi (Hall) ?
Spirifer grimesi Hall

- Spirifer tenuicostatus* Hall

- Spirifer rostellatus* Hall

- Spirifer logani* Hall

- Pseudosyrinx keokuk* Weller ?

- Reticularia pseudolineata* (Hall)

- Athyris lamellosa* (L'Eveille)

- Cliothyridina obmaxima* (McChesney)

- Cliothyridina parvirostra* (M. & W.)

Pelecypod

- Aviculopecten* sp.

Gastropods

- Straparollus* n. sp. cf. *S. latus* Hall

- Straparollus* sp.

- Platyceras paraliu* W. & W.

- Platyceras equilaterale* Hall ?

- Platyceras* sp.

- Platyceras* sp.

- Orthis cornuformis* (Winchell)

- Lepetopsis capulus* (Keyes)

Trilobite

- Griffithides portlocki* M. & W. ?

About 15 feet of light blue, medium to rather coarse-grained limestone which appears in an old quarry 1½ miles northwest of Greenfield, Dade county, may be assigned to the Keokuk on the basis of its contained fossils, as shown in the following list:

LVIII. Fossils from Keokuk Limestone at Quarry Northwest of Greenfield, Dade County

Corals

- Zaphrentis* sp. cf. *Z. varsoviensis* Worthen
Zaphrentis sp.
Triplophyllum dalei (E. & H.) ?
Amplexus fragilis White & St. John

Crinoid

- Megistocrinus* ? sp.

Bryozoans

- Fenestella multispinosa* Ulrich
Fenestella sp. 1, 2, 3
Polypora sp.
Hemitrypa sp.
Cystodictya lineata Ulrich

Brachiopods

- Orthis keokuk* (Hall)
Chonetes illinoisensis Worthen

- Productus ovatus* Hall

- Productus setigerus* Hall ?

- Pustula alternata* (N. & P.)

- Rhipidomella dubia* (Hall)

- Camarotoechia mutata* (Hall) ?

- Tetracamera subcuneata* (Hall)

- Dielasma* n. sp.

- Cyrtina* ? sp.

- Spirifer keokuk* Hall

- Spirifer tenuicostatus* Hall

- Spirifer rostellatus* Hall ?

- Reticularia pseudolineata* (Hall)

- Cliothyridina obmaxima* (McChesney) ?

Gastropods

- Platyceras paraliu* W. & W. ?

- Platyceras* sp.

- Lepetopsis capulus* (Keyes)

At Everton, in southeastern Dade county, a quarry in massive, gray crinoidal limestone was studied. At one place an exposure of 4 feet of limestone tentatively referred to the Upper

Burlington was found, but most of the beds appear to belong to the Keokuk. The following section was measured:

(55.) Section of Keokuk Limestone, One-half Mile Northwest of Everton, Dade County

		Thickness	
		Feet.	Inches.
Osage group			
Keokuk limestone			
4.	Limestone, light bluish gray, coarse-grained, crinoidal, very massive, band of nodular chert at base and thinner band 3 ½ feet above base. Contains large rugose and small crinoids.	6	
3.	Limestone, like 4 but in part finer grained intergrading with the coarse crinoidal layers. Stylolites common. <i>Orthotetes keokuk</i> Hall ranges throughout bed but is especially abundant in the upper 8 feet.	38	
2.	Chert and limestone, the chert occurring in large white to yellowish nodules and bands, the limestone fine-grained, blue, hard. The upper surface of the zone is nearly horizontal and even but the lower is very uneven.	½ to 4	
Upper Burlington (?) limestone			
1.	Limestone, light bluish gray, medium to coarse-grained, crinoidal, crystalline, massive. Poorly exposed. Contains <i>Spirifer grimesi</i> Hall.	4	

The following list of fossils collected from Bed 3, show many common Keokuk species:

LIX. Fossils from Bed 3, in Quarry at Everton, Dade County

Corals

- Zaphrentis* sp. 1, 2
Triplophyllum dalei (E. & H.) ?
Amplexus fragilis White & St. John
Palaeacis obtusus M. & W.

Bryozoans

- Leioclema* ? sp.
Cystodictya lineata Ulrich
Worthenopora spinosa Ulrich ?

Brachiopods

- Schellwienella* sp.
Orthotetes keokuk (Hall)
Chonetes illinoisensis Worthen
Productus sp. cf. *P. wortheni* Hall
Pustula alternata (N. & P.)
Rhipidomella dubia (Hall)
Rhipidomella sp.
Camarotoechia sp.

Cranaena globosa Weller ?

Dielasma sp.

Spiriferina sp.

Spirifer logani Hall

Spirifer keokuk Hall ?

Spirifer sp.

Reticularia pseudolineata (Hall)

Athyris lamellosa (L'Eveille) ?

Cliothyridina parvirostra (M. & W.)

Cliothyridina obmaxima (McChesney) ?

Composita globosa Weller ?

Pelecypods

Edmondia ? sp.

Aviculopecten colletti Worthen ?

Aviculopecten sp. 1, 2

Gastropod

Platyceras sp.

In Greene county the Keokuk limestone is well developed as indicated by faunal studies of Weller⁸⁴ and examination by the writer. The Short Creek oolite is present, its base marking the top of the Keokuk beds. Weller recognizes five faunal zones with occurrence of species as shown in the following table (revised by the writer):

LX. Fauna of the Keokuk Limestone in the Vicinity of Springfield, Greene County
(Weller)

Faunal zones	1	2	3	4	5
<i>Corals</i>					
<i>Zaphrentis centralis</i> E. & H.	x	—	x	x	—
<i>Zaphrentis varsoviensis</i> Worthen.	x	—	—	—	—
<i>Palaeacis obtusus</i> M. & W.	x	—	—	—	—
<i>Amplexus fragilis</i> White & St. John.	x	—	—	—	—
<i>Crinoids</i>					
<i>Actinocrinus multiradiatus</i> Shumard.	x	—	—	—	—
<i>Agaricocrinus americanus</i> Roemer.	x	x	—	—	—
<i>Batocrinus subtractus</i> White.	x	—	—	—	—
<i>Batocrinus trochiscus</i> M. & W.	x	—	—	—	—
<i>Batocrinus</i> sp.	—	x	—	—	—
<i>Uperocrinus nashvillae</i> (Troost).	—	x	—	—	—
<i>Uperocrinus pyriformis</i> (Shumard).	x	—	—	—	—
<i>Dizygocrinus biturbinatus</i> Hall.	—	x	—	—	—
<i>Dizygocrinus originarius</i> (Wachsmuth).	—	x	—	—	—
<i>Cyathocrinus iowensis</i> O. & S.	x	—	—	—	—
<i>Dorycrinus cornigerus</i> Hall.	x	—	—	—	—
<i>Platycrinus saffordi</i> Hall.	x	x	—	—	—
? <i>Synbathocrinus swallovi</i> Hall.	x	—	—	—	—
<i>Blastoids</i>					
? <i>Schizoblastus granulatus</i> (M. & W.).	x	x	—	—	—
? <i>Pentremites conoideus</i> Hall.	—	x	—	—	—
<i>Brachiopods</i>					
<i>Orthotetes keokuk</i> (Hall).	x	x	x	x	—
<i>Chonetes illinoisensis</i> Worthen.	x	—	x	x	—
<i>Productus burlingtonensis</i> Hall.	x	—	—	—	—
? <i>Productus marginicinctus</i> Prout.	—	—	—	x	—
<i>Productus setigerus</i> Hall.	x	x	—	—	x
<i>Productus</i> sp.	x	—	—	—	—
<i>Pustula alternata</i> (N. & P.).	x	—	—	—	—
<i>Rhipidomella dubia</i> (Hall).	—	x	x	x	—
<i>Schizophoria swallovi</i> (Hall).	x	—	—	—	—
<i>Camarotoechia mutata</i> (Hall).	—	x	—	—	—
<i>Tetracamera subtrigona</i> (M. & W.).	—	—	x	—	—
<i>Dielasma</i> sp.	—	x	x	—	x
<i>Spiriferina</i> sp.	—	x	—	—	—
<i>Spirifer grimesi</i> Hall.	x	—	—	—	—
<i>Spirifer logani</i> Hall.	x	x	x	—	—
<i>Spirifer tenuicostatus</i> Hall.	—	x	—	x	—
<i>Brachythyris suborbicularis</i> (Hall).	x	x	x	—	x
<i>Syringothyris</i> sp.	—	—	—	x	—
<i>Spiriferella neglecta</i> (Hall).	—	x	—	—	—
<i>Eumetria verneuilliana</i> M. & W.	—	x	—	—	—
<i>Reticularia pseudolineata</i> (Hall).	x	x	—	—	x
<i>Athyris lamellosa</i> (L'Eveille).	x	—	—	x	—
<i>Cliothyridina incrassata</i> (Hall).	x	x	—	x	x
<i>Cliothyridina royssii</i> (L'Eveille).	x	—	—	x	—

FAUNAL TABLE LX—Continued.

Faunal zones	1	2	3	4	5
<i>Pelecypods</i>					
Myalina keokuk Worthen.....	—	—	—	x	—
Aviculopecten magnus Swallow.....	x	—	—	—	x
Conocardium indianense Müller ?.....	—	—	—	—	x
<i>Gastropods</i>					
Platyceras equilaterale Hall.....	x	—	—	—	—
Platyceras fissurella Hall.....	x	x	—	—	—
Platyceras sp.....	—	—	—	x	—
<i>Trilobite</i>					
Girffithides bufo (M. & W.).....	x	—	x	—	—

In this list there are, especially in the lower zone, several species which are not observed ordinarily above the Upper Burlington and there are a few species (designated by ?) which are characteristic of the Warsaw or higher zones. These discrepancies may indicate need of revised identification, in part they may be due to miscorrelation of the beds at one or more of the localities studied, or they may represent actual distribution of the species. In addition to the species recorded above, the writer collected typical *Productus wortheni*, several species of *Fenestella*, *Hemitrypa*, *Cranaena globosa* and a number of crinoids which have not been determined. The aspect of the fauna is clearly younger than Burlington.

As indicated by the foregoing faunal lists, the Keokuk contains numerous distinguishing species which are not known in the underlying Burlington limestone, and each of the invertebrate phyla are represented by new types. There is particularly a development of the bryozoans; *Archimedes* and other genera first appear. Among the corals *Palaeacis obtusus*, new species of *Zaphrentis* and *Monilopora beecheri* mark the Keokuk. Some of the Upper Burlington crinoids lived in the succeeding epoch, but there is a distinct change in the composition and characteristics of the Keokuk crinoid fauna. In general the early Osage crinoids are simpler, smaller and less ornamented than those that appeared later. The crinoids were abundant both in Keokuk and Burlington times, although only a few species are recorded in the writer's collections. Most of the bryozoans of the Keokuk represent species which are not known below this horizon. The abundance of this group, and especially the

presence of such forms as *Archimedes* and *Worthenopora*, indicate an age younger than Burlington. Among the brachiopods common and more or less strongly distinguishing Keokuk markers are *Orthotetes keokuk*, *Productus wortheni*, *P. mesjalis*, *Pustula biseriata*, *Rhipidomella dubia*, *Camarotoechia mutata*, *Tetracamera subcuneata*, *T. subtrigona*, *Spirifer keokuk*, *S. logani*, *S. rostellatus*, *Eumetria verneuiliana*, *Reticularia pseudolineata*, and *Cliothyridina parvirostra*. However, several of these species, as well as new pelecypods, gastropods and other classes, lived beyond Keokuk time into the Warsaw stage.

In lithologic character, conformity with the Burlington and Warsaw in the type region, and in general faunal composition the Keokuk is clearly related to the Burlington and is naturally classed with it in the Osage group. However, as has already been noted, there is found in southwestern Missouri and elsewhere an hiatus representing apparently all of the Upper Burlington and perhaps more deposits of other regions.

Correlation. The Keokuk strata of Missouri are continuous with those of southeastern Iowa. Many well borings in the region between the outcrops in the two states have penetrated the Keokuk though commonly it is not clearly distinguished from the contiguous limestones. The faunas of the Missouri and Iowa Keokuk show close similarity. Much the same conditions prevailed throughout the central and southern Mississippi Valley region, including Kansas, Oklahoma, Arkansas, Illinois, Missouri and Iowa. The sea was widespread, probably covering most of Ozarkia and reaching eastward across Kentucky, Tennessee and Alabama. In parts of the submerged area, especially toward the northeast near the Cincinnati arch, clastic deposits were forming during Keokuk time (Kenwood sandstone, Rosewood shale, Holtsclaw sandstone) but farther south, as in Tennessee and Alabama the main part of the Fort Payne chert consisting of limestone and chert, more or less resembling the cherty Boone formation of southwest Missouri, is of Keokuk age. Probably a large part of the Mississippian limestone which is encountered in hundreds of wells in the oil fields of eastern Kansas and Oklahoma belong to the Keokuk formation.

WARSAW LIMESTONE

General character and classification. The name Warsaw was first applied by James Hall¹⁷ in 1856 to strata above the "geodiferous bed" at the top of the Keokuk limestone. Later studies⁵⁹ have shown that the geode bed should be regarded as a part of the Warsaw limestone, and thus defined, the formation consists at the type locality, Warsaw, Illinois, of about 80 feet of limestone and shale. Worthen^{79b} in 1866 did not recognize the Warsaw as a distinct stratigraphic division but included the "blue calcareo-argillaceous shales and magnesian and arenaceous limestones at Warsaw," in the lower part of his St. Louis group. This usage was followed by White⁷³ in the second geological survey of Iowa and by a number of others so that, especially in the description of fossils, some confusion as to true stratigraphic relations has resulted. In Missouri, Shumard⁴⁴ (1871) distinguished the "Third Archimedes" (Warsaw) limestone as a division distinct from the overlying St. Louis limestone but Broadhead⁷ (1874) classified the Mississippian rocks essentially as Worthen had done. However, he recognized the Warsaw limestone as a separate division correlative in rank with the St. Louis limestone in the "St. Louis group." Williams^{75a} (1891) after a review of the classification of the Mississippian, proposed a division of the system in which the Warsaw limestone (part) was placed in the "Genevieve group" with the St. Louis and Chester. Ulrich⁵⁵ (1904) proposed the name Meramec group to include the Warsaw, Spergen and St. Louis formations which are exposed on Meramec river near St. Louis.

The type Warsaw, which has recently been described in some detail by Van Tuyl,⁵⁹ was examined by the writer in company with Van Tuyl. The beds classed as Warsaw in this report are distinguished faunally and in part lithologically from the underlying Keokuk formation. In general there is more or less shale in the Warsaw but in southwestern Missouri, as in southern Illinois and parts of Indiana, Kentucky and Alabama, the Warsaw consists largely of crystalline limestone with very little clastic material. On the other hand the Keokuk in Kentucky and adjacent areas is composed largely of shale and some sandstone.¹⁰ The writer's study of the Warsaw has strongly impressed upon him the relationship of this formation with the deposits of the Osage group and its apparent distinctness from succeeding beds. The Burlington, Keokuk and Warsaw

bear lithologic resemblances which suggest general similarity in physical and biotic conditions during the time of their accumulation; the dense, fine-grained texture of the succeeding rocks shows a well marked change in these conditions. In southwestern Missouri, where Warsaw fossils have been recognized by Ulrich, Weller and some others, the Boone limestone comprises a supposedly almost indistinguishable aggregate of Burlington, Keokuk and Warsaw beds. Indeed, the existence of well developed Warsaw in this region has not been generally recognized.

As shown in the faunal comparison of Keokuk and Warsaw on a succeeding page, there are differences in the faunas of these formations. Some species, such as *Palaeacis obtusus*, *Productus viminalis*, *Tetracamera subtrigona*, *Spirifer logani*, numerous crinoids and other fossils, are common in the Keokuk and do not range upward into Warsaw beds. Other species such as *Pentremites conoideus*, *Archimedes wortheni*, *Fenestralia sanctiludovici*, *Spirifer bifurcatus*, *S. lateralis* and *Productus magnus* do not occur in the Keokuk but are more or less common in the Warsaw. Some forms that are abundant in one formation are rare in the other. However, the identifications of Van Tuyl for southeastern Iowa and western Illinois, and those of the writer for Missouri, indicate a preponderant element in the fauna which is in common. The general composition of the Keokuk fauna resembles that of the Warsaw, each class of invertebrates being represented in the one to a degree more or less corresponding to that in the other. The camerate crinoids which are so distinctive an element of the Osage faunas continue, though with indications of approaching extinction, into the Warsaw. The prominence of Keokuk bryozoans is matched by abundance of Warsaw bryozoans, most of them belonging to the same species.

There is no evidence of unconformity between Keokuk and Warsaw in the type region described by Van Tuyl, but the lower formation grades into the upper. The writer has seen no indication of a stratigraphic break in northeastern or central Missouri localities where the Keokuk and Warsaw are exposed, but in the southwestern part of the state there seems to have been at least a short time of exposure and erosion of Keokuk beds before the deposition of the Warsaw. In keeping with these observations the distribution of the Warsaw appears to be much like that of the underlying Osage, but it is different in

notable degree from that of the next younger formations with which it has been classed.

In contrast with the relationships which have been indicated, there seem to be significant faunal, lithologic and stratigraphic reasons for separating the Warsaw from the St. Louis and possibly also from the Spergen. The large Spergen fauna contains many species that are known in the Warsaw, representing, apparently, rather unusual physical conditions, but a large element is restricted to the Spergen. Butts¹⁰ has advanced the view that the Spergen is really a specialized facies of upper Warsaw deposits; it is essentially local. Ulrich and others have interpreted the Spergen as a formation distinctly younger than Warsaw, localized in its most characteristic development but overlapping especially to the west and south. In southeastern Iowa Van Tuyl⁵⁰ describes thin sandy, shaly and limy deposits, more or less cross-bedded and showing marked local variations, which he assigns to the Spergen. These beds are said to rest unconformably on Warsaw and are unconformably overlain by conglomeratic St. Louis limestone. In central and southwestern Missouri no Spergen or St. Louis rocks are known, nor, excepting possible Moorefield shale equivalents in eastern Oklahoma, are these formations known anywhere beneath Kansas and Oklahoma where hundreds of borings have penetrated the Mississippian rocks. This indicates that the Warsaw is followed by a very important stratigraphic break. The St. Louis contains a much smaller fauna than the limestones below it and in it almost none of the familiar Keokuk or Warsaw species occur.

In view of these considerations, the writer believes that the Warsaw limestone should be referred to the Osage group. It is worthy of note that the faunal and stratigraphic separation of the Keokuk and Burlington is much more distinct in the Iowa-Missouri, and most other regions, than that of the Keokuk and Warsaw. Doctor Weller concurs in the estimate of small time value for the Keokuk-Warsaw break (where recognized at all), and believes strongly that no evidence of a hiatus of inter-systemic importance, as postulated by Schuchert and Ulrich exists. He would, however, retain the present classification of the beds which assigns Keokuk to the Osage group and Warsaw to the Meramec group.

Distribution and thickness. Strata of Warsaw age known to be present in northeastern Missouri north of Hannibal, in

Lincoln county and near St. Louis, in Boone, Howard, Cooper and possibly other counties of central Missouri and they are widespread in the southwestern part of the state. The thickness is in most places not readily determined because of incomplete exposures and, since the Warsaw is the youngest Mississippian present in most of the places where it occurs, a variable amount of the formation has been removed by erosion. In the northeast part of Missouri its average total thickness is about 70 feet. In the central part of the state a lesser thickness has been observed but it is possible that the complete thickness of the formation is 50 feet or more. The Warsaw of southwestern Missouri is probably about 100 feet in total thickness.

Lithologic character. The Warsaw consists of fine to coarse crystalline or subcrystalline limestone, in part more or less crinoidal but generally not like the Burlington. Beds are commonly less massive than the underlying Osage and there are frequent thin seams or beds of somewhat limy shale. Bluish gray to buff tones prevail. Chert occurs in nodules or in bands, and is essentially like that in associated Mississippian formations. In part of the southwestern Missouri district the limestone is thick-bedded, pure, and non-cherty. This rock makes an excellent building stone and there are large quarries, especially in the vicinity of Carthage, Jasper County. Stylolites are common but are not a serious defect in the stone. The crystalline character of the limestone permits a high polish and the formation is the source of much interior marble. An oolitic limestone (Short Creek member) 2 to 8 feet thick, bluish gray on fresh exposure, weathering yellowish white comprises the basal member of the formation in much of southwestern Missouri.

Stratigraphic sections and paleontologic character. The nature of the Warsaw beds, as observed by the writer at various representative exposures in Missouri is indicated in the following sections and faunal lists. In Lincoln county partial exposures of the Warsaw were examined near Troy and Moscow Mills.

(56.) Section of Warsaw Limestone at Quarry West of Moscow Mills, Lincoln County.
Sec. 4, T. 48 N., R. 1 E.

Osage group Warsaw limestone	Thickness	
	Feet.	Inches.
8. Limestone, light bluish drab to gray, weathering buff, subcrystalline, hard, thin-bedded, partially covered.....	3	
7. Limestone like 8 but massive, fossiliferous.....	6	
6. Covered.....	5	
5. Limestone, bluish gray, medium to fine-grained, hard, a single massive layer.....	1	6

	Thickness	
	Feet.	Inches.
4. Shale, bluish to brownish gray, clayey but containing seams of yellowish sandy shale, poorly exposed.....	1	6
3. Limestone, grayish brown, fine-grained, subcrystalline, hard, forms projecting ledge, massive.....	3	
2. Limestone buff, earthy, compact, grading near top into shaly limestone.....	2	
1. Sandstone, buff, shaly in upper part grading into sandy shale. Exposed.....	1	9

Fossils collected from beds 2, 4, 7 and 8 are listed below:

LXI. Fossils from the Warsaw Limestone West of Moscow Mills, Lincoln County

Beds	2	4	7	8
<i>Corals</i>				
Zaphrentis varsoviensis (Worthen).....	—	—	—	x
Zaphrentis sp.....	—	x	—	—
Zaphrentis sp.....	—	—	x	—
Monilopora beecheri Grabau.....	x	—	—	x
Monilopora sp.....	—	x	—	—
Syringopora sp.....	—	x	—	—
<i>Echinoid</i>				
Archeocidaris sp.....	—	—	—	x
<i>Bryozoans</i>				
Fistulopora sp.....	—	—	—	x
Tabulipora sp.....	—	—	—	x
Tabulipora ? sp.....	x	—	—	—
Leioclema sp.....	—	—	x	—
Fenestella serratula Ulrich.....	x	—	x	x
Fenestella serratula var. quadrata Cumings.....	—	—	—	x
Fenestella triserialis Ulrich.....	?	—	—	x
Fenestella tenax Ulrich.....	?	—	—	x
Fenestella compressa var. elongata.....	x	—	—	—
Fenestella multispinosa Ulrich.....	x	—	?	x
Fenestella sp.....	—	—	—	x
Polypora varsoviensis Prout.....	?	—	?	x
Hemitrypa pateriformis Ulrich ?.....	—	—	—	x
Hemitrypa sp.....	x	—	—	—
Hemitrypa sp.....	—	—	—	x
Rhombopora bedfordensis Cumings.....	—	—	—	x
Rhombopora sp.....	—	—	—	x
Cystodictya lineata Ulrich.....	x	—	—	—
Cystodictya lineata var. major Ulrich.....	x	—	—	—
Glyptopora sp.....	x	—	—	—
Worthenopora spinosa Ulrich.....	—	—	—	x
<i>Brachiopods</i>				
Schellwienella ? sp.....	x	—	—	—
Streptorhynchus sp.....	x	—	—	—
Streptorhynchus sp.....	—	—	—	x
Chonetes sp.....	x	—	—	—
Productus setigerus Hall.....	x	—	—	—
Productus sp.....	x	—	—	—
Pustula indianensis (Hall).....	x	—	—	—

FAUNAL TABLE LXI—Continued.

Beds	2	4	7	8
<i>Brachiopods—Cont'd</i>				
Pustula sp.	—	—	x	—
Pustula sp.	—	—	—	x
Rhipidomella dubia (Hall)	—	—	x	—
Rhipidomella sp.	x	—	—	—
Camarotoechia mutata (Hall)	x	—	x	x
Camarotoechia grosvenori (Hall)	x	—	—	—
Camarotoechia sp.	—	—	—	x
Tetracamera subcuneata (Hall)	x	—	?	—
Tetracamera sp. cf. T. missouriensis Weller.	x	—	—	—
Tetracamera sp.	—	—	—	x
Cranaena sp.	x	—	—	—
Spiriferina sp.	—	—	x	—
Spiriferina sp.	—	—	—	x
Spirifer keokuk Hall.	?	—	?	cf
Spirifer lateralis Hall.	?	—	x	—
Spirifer sp. cf. S. bifurcatus Hall.	—	—	x	—
Spirifer tenuicostatus Hall.	—	—	x	—
Spirifer sp.	—	—	x	—
Spirifer sp.	—	—	—	x
Reticularia sp.	x	—	—	—
Eumetria verneuiliana (Hall)	—	—	x	—
Cliothyridina hirsuta (Hall)	—	—	—	x
<i>Pelecypod</i>				
Conocardium sp.	x	—	—	—

(57.) Section of Warsaw Limestone in Quarry, One-fourth Mile South of St. Louis and Hannibal Depot, Troy, Lincoln County

	Thickness	
	Feet.	Inches.
Osage group		
Warsaw limestone		
3. Limestone, buff to bluish gray, medium-grained, subcrystal-line, massively bedded with thin shaly partings between beds. <i>Rhipidomella dubia</i> (Hall) very abundant.	2	6
2. Limestone, chert and shale. The limestone is light buff, siliceous, very nodular and irregular; chert bluish gray, hard, flinty, occurs in nodules and thin bands; shale bluish, hard, calcareous. Contains numerous bryozoans, rather poorly pre-served except in the chert.	2	
1. Limestone, dark bluish gray, hard, siliceous, fine-grained, compact, rather massive beds. In places contains intercalated beds of medium-grained crystalline limestone.	5	

LXII. Fossils from Warsaw Limestone, South of Troy

Beds	1	2	3
<i>Corals</i>			
<i>Zaphrentis varsoviensis</i> (Worthen) ?	—	x	x
<i>Zaphrentis</i> sp.	x	—	—
<i>Triplophyllum dalei</i> (E. & H.) ?	—	x	—
<i>Syringopora</i> sp.	—	—	x
<i>Crinoid</i>			
<i>Synbathocrinus blairi</i> Miller ?	—	—	x
<i>Bryozoans</i>			
<i>Fistulipora</i> sp.	—	x	—
<i>Tabulipora</i> sp.	—	—	x
<i>Tabulipora</i> ? sp.	—	x	—
<i>Fenestella multispinosa</i> Ulrich	—	x	?
<i>Fenestella serratula</i> Ulrich	x	x	x
<i>Fenestella triserialis</i> Ulrich ?	—	x	—
<i>Fenestella exigua</i> Ulrich	—	x	—
<i>Fenestella tenax</i> Ulrich	?	x	—
<i>Fenestella</i> sp.	—	—	x
<i>Fenestella</i> sp.	—	—	x
<i>Hemitrypa</i> sp.	—	—	x
<i>Archimedes owenanus</i> Hall	—	—	x
<i>Archimedes grandis</i> Ulrich ?	—	—	x
<i>Archimedes wortheni</i> Hall ?	x	—	—
<i>Archimedes</i> sp.	—	x	—
<i>Rhombopora attenuata</i> Ulrich ?	—	x	x
<i>Rhombopora</i> sp.	—	x	—
<i>Cystodictya lineata</i> Ulrich	—	—	x
<i>Worthenopora spinosa</i> Ulrich	—	—	x
<i>Brachiopods</i>			
<i>Productus setigerus</i> Hall ?	—	—	x
<i>Productus</i> sp.	—	—	x
<i>Rhipidomella dubia</i> (Hall)	—	x	x
<i>Camarotoechia mutata</i> (Hall)	—	x	x
<i>Camarotoechia</i> sp.	—	—	x
<i>Spiriferina</i> sp.	—	x	—
<i>Spirifer lateralis</i> Hall	x	?	—
<i>Spirifer bifurcatus</i> Hall ?	—	x	—
<i>Spirifer</i> sp. cf. <i>S. keokuk</i> Hall	—	x	x
<i>Spirifer</i> sp. cf. <i>S. pellaensis</i> Weller	—	x	—
<i>Spirifer</i> sp.	x	—	—
<i>Brachythyris subcardiformis</i> (Hall) ?	x	—	—
<i>Brachythyris</i> sp.	—	—	x
<i>Syringothyris</i> sp.	—	x	—
<i>Spiriferella</i> sp.	—	—	x
<i>Reticularia pseudolineata</i> (Hall)	—	x	—
<i>Cliothyridina</i> sp.	—	x	—
<i>Pelecypods</i>			
<i>Conocardium meekanum</i> Whitfield ?	x	—	—
<i>Aviculopecten niotensis</i> Worthen	—	—	x

FAUNAL TABLE LXII—Continued.

Beds	1	2	3
<i>Pelecypods—Cont'd</i>			
Aviculopecten sp.	—	—	x
Lithophagus illinoisensis Worthen.	—	—	x
<i>Trilobite</i>			
Griiffithides sp.	—	—	x

A typical exposure of beds classed as Warsaw, from a locality west of Boonville, Cooper county, is described in section 58, and a rather abundantly fossiliferous outcrop south of Lisbon in western Howard county shows best the faunal character of these beds in the central part of Missouri. The studies of the writer were not sufficiently detailed in this region to ascertain the stratigraphic position of the Boonville crinoid beds which have supplied a number of species, some found in the Warsaw of Indiana and Kentucky, others restricted, so far as yet known, to this locality. Among these Boonville crinoids are *Dizygocrinus whitei* (W. & S.) found also in Warsaw beds at Spergen Hill, Indiana, and Barren county, Kentucky; *D. originarius* (W. & S.) reported from the top of the Keokuk of Canton, Indiana; *D. originarius* var. *adultus* (W. & S.), also from Upper Keokuk beds of Lawrence county, Indiana; *D. unionensis* (Worthen) a widespread and characteristic Warsaw species reported from Huntsville, Alabama, Lee county, Virginia, and Pulaski county, Kentucky; *D. unionensis* var. *divalis* (Miller) known only from Huntsville, Alabama, and Boonville, Missouri; *D. euconus* var. *abscissus* (Rowley and Hare) from the Upper Keokuk and Lower Warsaw of Taylor county, Kentucky; *Taxocrinus giddingei* (Hall) from the Warsaw and top of Keokuk in Warshington county, Indiana. Other Boonville crinoids are *Dizygocrinus gurveyi* (Miller), and *D. gorbyi* (Miller), *Cyathocrinus boonvillensis* Miller, *Batocrinus vicinus* M. & G., *B. vetustus* M. & G., *B. veterator* M. & G., *B. venustus* M. & G., *B. strenurs* M. & G., *B. stelliformis* M. & G., *B. serratus* M. & G., *B. sampsoni* M. & G., *B. procerus* M. & G., *B. polydactylus* M. & G., *B. peculiaris* M. & G., *B. parilis* M. & G., *B. nitidulus* M. & G., *B. modestus* M. & G., *B. insuetus* M. & G., *B. inopinatus* M. & G., *B. inconsuetus* M. & G., *B. ignotus* M. & G., *B. heteroclitus* M. & G., *B. delicatulus* M. & G., *B. broadheadi* M. & G., *Barycrinus*

stellatus (Hall), *B. hoveyi* (Hall), *B. boonvillensis* Miller, *B. blairi* Miller, *Dichocrinus parvulus* Miller, *D. humbergi* Miller, *D. ficus* Lyon and Casseday, *D. blairi* Miller, *Forbesiocrinus elegantulus* Miller, *Platycrinus boonvillensis* White, *P. pentagonus* Miller, *Poteriocrinus agnatus* Miller, *P. boonvillensis* Miller, *P. brittsi* Miller, *P. labyrinthicus* M. & G., *P. lautus* M. & G., *P. neglectus* M. & G., *Rhodocrinus coxanus* Worthen, *R. parvus* Miller, *Scaphiocrinus boonvillensis* Miller, *S. constrictus* Miller, *S. gorbyi* Miller, *Synbathocrinus swallowi* Hall, *S. blairi* Miller and *Woodocrinus pocillum* Miller. It is not certain that this fairly large crinoid assemblage is all from the same zone at Boonville. Both Keokuk and Warsaw beds are represented in the area. Since some of the forms that occur in other areas are found in Warsaw beds or not lower than uppermost Keokuk, at least a part of this fauna belongs to the Warsaw. Associated with the crinoids is the characteristic Warsaw (or Spergen) blastoid *Pentremites conoideus* Hall.

At a point along the Missouri Pacific track about one-eighth mile west of the M., K. & T. Railroad bridge the following section was measured:

(58.) Section of Warsaw Limestone, West of Boonville

Osage group		Thickness	
		Feet.	Inches.
Warsaw limestone			
	7. Limestone, gray to blue, weathering buff, and chert in nodular beds, rather thin-bedded.	4	6
	6. Limestone, light gray, medium-grained, uniform texture, hard, massive.	1	2
	5. Shale, gray to buff, calcareous with thin interbedded shaly limestone.	5	
	4. Limestone, rather dark bluish gray, medium-grained, crinoidal, chert layer at top.	3	4
	3. Shale, bluish gray, calcareous, with thin somewhat nodular beds of limestone, contains bryozoans.	1 to 2	
	2. Limestone, bluish weathering light gray, in two beds of nearly equal thickness, shaly parting. Upper bed varies in thickness from 6 to 20 inches.	1 to 2	
	1. Limestone like above, medium-grained, even texture, thick chert bed near middle.	4	3

Fossils collected from beds 3 and 4 are recorded in the following lists:

LXIII. Fossils from the Warsaw Limestone, West of Boonville

Beds	3	4	5
<i>Corals</i>			
Zaphrentis varsoviensis Worthen.....	?	x	—
Amplexus sp.	x	—	—
Monilopora beecheri Grabau.....	—	—	x
<i>Bryozoans</i>			
Tabulipora ? sp.....	—	—	x
Fenestella multispinosa Ulrich.....	x	—	x
Fenestella triserialis Ulrich.....	x	—	x
Fenestella serratula Ulrich.....	x	—	x
Fenestella serratula var. quadrata Cumings.....	x	—	x
Fenestella limitaris Ulrich.....	—	—	x
Fenestella compressa var. elongata Cumings.....	x	—	—
Fenestella sp.....	x	x	x
Polypora retrorsa Ulrich.....	x	—	—
Polypora striata Cumings ?.....	—	—	x
Polypora varsoviensis Prout.....	—	—	x
Polypora sp.....	x	—	—
Hemitrypa proutana Ulrich.....	x	—	—
Hemitrypa pateriformis Ulrich ?.....	x	—	x
Hemitrypa sp.....	x	—	—
Archimedes owenanus Hall.....	x	—	x
Rhombopora attenuata Ulrich.....	x	x	—
Rhombopora varians Ulrich.....	x	—	x
Rhombopora ? asperula Ulrich.....	x	—	—
Rhombopora sp.....	—	x	—
Rhombopora n. sp.....	—	—	x
Cystodictya lineata Ulrich.....	x	—	x
Cystodictya pustulosa Ulrich.....	—	—	x
Worthenopora spinosa Ulrich.....	—	—	x
<i>Brachiopods</i>			
Streptorhynchus sp.....	—	x	—
Pustula alternata (N. & P.).....	x	—	—
Pustula biseriata (Hall).....	—	x	—
Rhipidomella dubia (Hall).....	—	x	—
Camarotoechia mutata (Hall).....	x	—	—
Spiriferina sp.....	—	—	x
Spirifer rostellatus Hall.....	x	—	—
Spirifer tenuicostatus Hall.....	x	—	x
Composita globosa Weller.....	?	x	—
<i>Gastropod</i>			
Platyceras sp.....	x	—	x

(59.) Section of Warsaw Beds at Old Quarry One and One-half Miles South of Lisbon,
Howard County. Sec. 26, T. 50 N., R. 18 W.

	Thickness	
	Feet.	Inches.
Osage group		
Warsaw limestone		
4. Limestone, light bluish gray weathering buff, medium-grained, even texture, in beds 6 to 12 inches thick, fossiliferous.	2	6
3. Shale and limestone, the shale chiefly dark bluish, clayey with interbedded buff and gray streaks; the limestone in thin beds intercalated in shale at intervals of 5 to 6 inches in lower part, almost absent in upper part. Thin nodules of reddish jasperoidal chert in part of the limestone. Contains numerous fossils.	10	4
2. Limestone and shale, the limestone light bluish gray, medium-grained, crystalline, in thin layers 3 to 4 inches thick in lower part, up to 9 inches in upper part; the shale, bluish, clayey, slightly calcareous, occurring as thin beds between the limestone layers. Fossiliferous.	15	6
1. Limestone, bluish in part, medium-grained, crystalline, massive, cherty, in part fine-grained, impure, shaly, grading to calcareous shale. Fossiliferous. Exposed.	10	

LXIV. Fossils from the Warsaw Limestone, 1½ Miles South of Lisbon

Beds	1	2	3	4
<i>Sponge</i>				
Hindia ? sp.	—	—	—	x
<i>Corals</i>				
Zaphrentis varsoviensis (Worthen)	x	x	x	x
Zaphrentis sp.	—	—	—	x
Monilopora beecheri Grabau.	—	—	x	x
Monilopora sp.	—	—	—	x
<i>Blastoid</i>				
Pentremites conoideus Hall.	—	x	—	x
<i>Crinoids</i>				
Batocrinus sampsoni M. & G. ?	—	—	—	x
Actinocrinus sp.	—	—	—	x
Platycrinus sp.	—	—	x	—
Platycrinus sp.	—	—	—	x
Synbathocrinus sp.	—	—	—	x
Barycrinus boonvillensis Miller.	—	—	—	x
Cyathocrinus sp.	—	—	—	x
<i>Echinoid</i>				
Archeocidaris sp.	x	x	—	x
<i>Bryozoans</i>				
Fistulipora sp.	—	x	—	—
Tabulipora sp.	—	—	—	x
Tabulipora sp.	—	—	—	x
Tabulipora sp.	—	x	—	—
Leioclema punctatum (Hall)	—	x	—	x
Fenestella cingulata Ulrich.	x	—	—	—
Fenestella multispinosa Ulrich.	x	x	x	x
Fenestella triserialis Ulrich.	x	x	—	—

FAUNAL TABLE LXIV—Continued.

Beds	1	2	3	4
<i>Bryozoans—Cont'd</i>				
<i>Fenestella serratula</i> Ulrich.....	x	x	—	x
<i>Fenestella serratula</i> var. <i>quadrata</i> Cumings.....	—	—	—	x
<i>Fenestella compressa</i> Ulrich.....	—	—	—	x
<i>Fenestella compressa</i> var. <i>elongata</i> Cumings.....	—	x	—	—
<i>Fenestella tenax</i> Ulrich.....	—	x	x	x
<i>Fenestella regalis</i> Ulrich.....	—	—	—	x
<i>Fenestella limitaris</i> Ulrich ?.....	—	—	—	x
<i>Fenestella funicula</i> Ulrich.....	—	—	—	x
<i>Fenestella elevatipora</i> Ulrich.....	—	—	—	x
<i>Fenestella</i> sp. cf. <i>F. filistriata</i> Ulrich.....	—	—	—	x
<i>Fenestella</i> sp.....	—	—	—	x
<i>Fenestella</i> sp.....	—	—	—	x
<i>Hemitrypa proutana</i> Ulrich.....	—	—	x	x
<i>Hemitrypa</i> sp.....	x	—	—	—
<i>Hemitrypa</i> sp.....	—	x	—	—
<i>Hemitrypa</i> sp.....	—	—	x	—
<i>Hemitrypa</i> sp.....	—	—	—	x
<i>Archimedes wortheni</i> Hall.....	x	—	—	?
<i>Archimedes owenanus</i> Hall.....	—	x	—	x
<i>Fenestralia sancti-ludovici</i> Prout.....	x	—	—	x
<i>Polypora varsoviensis</i> Prout.....	x	x	x	x
<i>Polypora spininodata</i> Ulrich ?.....	x	—	—	—
<i>Polypora striata</i> Cumings ?.....	x	—	—	—
<i>Polypora simulatrix</i> Ulrich.....	—	x	—	?
<i>Polypora halliana</i> Ulrich ?.....	—	x	—	—
<i>Polypora</i> n. sp.....	—	x	—	—
<i>Polypora</i> sp.....	—	x	—	—
<i>Pinnatopora</i> sp.....	—	x	—	—
<i>Ptilopora prouti</i> Hall.....	—	—	—	x
<i>Ptilopora</i> sp.....	—	x	—	—
<i>Ptilopora</i> sp.....	—	—	—	x
<i>Rhombopora varians</i> Ulrich.....	x	x	—	x
<i>Rhombopora attenuata</i> Ulrich.....	—	—	—	x
<i>Rhombopora</i> ? <i>asperula</i> Ulrich.....	x	—	—	—
<i>Rhombopora</i> sp.....	—	x	—	—
<i>Rhombopora</i> sp.....	—	—	x	—
<i>Rhombopora</i> sp.....	—	—	—	x
<i>Cystodictya pustulosa</i> Ulrich ?.....	x	—	—	—
<i>Cystodictya lineata</i> Ulrich.....	x	x	x	x
<i>Cyclopora</i> sp.....	—	x	—	—
<i>Cyclopora</i> sp.....	—	—	—	x
<i>Proutella discoidea</i> (Prout).....	—	—	—	x
<i>Worthenopora spinosa</i> Ulrich.....	—	—	x	x
<i>Brachiopods</i>				
<i>Orbiculoidea</i> sp.....	—	—	x	—
<i>Productus wortheni</i> Hall.....	—	x	x	x
<i>Productus</i> sp. cf. <i>P. setigerus</i> Hall.....	—	x	—	—
<i>Productus</i> sp.....	—	x	—	—

FAUNAL TABLE LXIV—Continued.

Beds	1	2	3	4
<i>Brachiopods—Cont'd</i>				
<i>Productus</i> sp.	—	—	x	—
<i>Pustula biseriata</i> (Hall)	—	x	x	x
<i>Pustula</i> sp.	—	—	x	—
<i>Pustula</i> sp.	—	—	—	x
<i>Rhipidomella dubia</i> (Hall)	—	—	—	x
<i>Camarotoechia mutata</i> (Hall)	—	—	x	x
<i>Camarotoechia grosvenori</i> (Hall)	—	—	x	—
<i>Allorhynchus macrum</i> (Hall)	—	—	x	—
<i>Tetracamera</i> sp. cf. <i>T. subcuneata</i> (Hall)	—	—	—	x
<i>Dielasma</i> ? sp.	—	—	x	x
<i>Spiriferina</i> sp.	—	—	—	x
<i>Spiriferina</i> ? sp.	—	—	x	x
<i>Spirifer tenuicostatus</i> Hall.	—	x	x	x
<i>Spirifer washingtonensis</i> Weller.	—	—	—	x
<i>Spirifer subaequalis</i> Hall.	—	—	—	x
<i>Spirifer keokuk</i> Hall.	—	—	—	x
<i>Spirifer</i> sp. cf. <i>S. keokuk</i> Hall.	x	x	—	x
<i>Spirifer</i> sp. cf. <i>S. leidyi</i> N. & P.	—	—	x	—
<i>Spirifer</i> sp.	x	—	—	—
<i>Brachythyris</i> sp.	—	—	x	—
<i>Ambocoelia</i> ? sp.	—	—	—	x
<i>Reticularia pseudolineata</i> (Hall)	—	x	x	x
<i>Eumetria verneuiliana</i> (Hall)	—	—	x	—
<i>Athyris</i> sp.	—	—	—	x
<i>Cliothyridina parvirostra</i> (M. & W.)	—	x	?	x
<i>Cliothyridina</i> sp.	—	x	—	—
<i>Composita globosa</i> Weller.	—	—	—	x
<i>Composita</i> sp.	—	—	x	—
<i>Pelecypods</i>				
<i>Aviculopecten</i> sp.	—	—	x	—
<i>Aviculopecten</i> sp.	—	—	x	—
<i>Gastropods</i>				
<i>Bellerophon</i> sp.	—	—	x	—
<i>Naticopsis</i> ? sp.	—	—	—	x
<i>Platyceras paraliium</i> W. & W.	—	—	—	x
<i>Platyceras</i> sp.	—	—	x	—
<i>Pteropod</i>				
<i>Conularia missouriensis</i> Swallow.	—	—	—	x
<i>Trilobite</i>				
<i>Griffithides</i> sp.	—	—	x	—

Fossils collected from the Short Creek oolite and overlying crystalline limestone beds of the Warsaw at the Marblehead quarry north of Sarcxie, Jasper County (stratigraphic section on page 214) are recorded in the following list:

LXV. Fossils from the Short Creek Oolite and Overlying Limestone of the Boone Formation at the Marblehead Lime Quarry, 1 mile North of Sarcoxie, Jasper County

	Short Creek 4	Warsaw 5
<i>Corals</i>		
Zaphrentis varsoviensis (Worthen)	—	x
Zaphrentis sp.	—	x
Amplexus fragilis White & St. John	—	x
<i>Crinoid</i>		
Platycrinus sp.	—	x
<i>Bryozoans</i>		
Fistulipora sp.	x	—
Tabulipora ? sp.	x	—
Fenestella serratula Ulrich ?	—	x
Fenestella compressa var. elongata Cumings ?	—	x
Glyptopora sp.	x	—
Worthenopora spinosa Ulrich	—	x
<i>Brachiopods</i>		
Schellwienella sp.	x	—
Streptorhynchus ruginosum (Hall & Clarke)	x	—
Orthotetes keokuk (Hall)	x	x
Chonetes illinoisensis Worthen	—	x
Productus ovatus Hall	x	x
Productus wortheni Hall	x	x
Productus sp.	—	x
Productus sp.	—	x
Pustula biseriata (Hall)	—	x
Pustula sp.	—	x
Rhipidomella dubia (Hall)	x	—
Rhipidomella sp.	—	x
Camarotoechia grosvenori (Hall) ?	—	x
Camarotoechia mutata (Hall)	x	x
Allorhynchus macrum (Hall)	x	—
Tetracamera subcuneata (Hall)	x	—
Dielasma inflatum Weller ?	x	—
Dielasma arkansanum Weller ?	—	x
Spiriferina ? sp.	x	—
Spirifer keokuk Hall	x	—
Spirifer bifurcatus Hall ?	—	—
Spirifer sp.	x	—
Spirifer sp.	—	x
Brachythyris sp.	—	x
Pseudosyrinx keokuk Weller ?	x	—
Reticularia pseudolineata (Hall)	x	—
Eumetria verneuilliana (Hall)	x	—
Nucleospira ? sp.	—	x
Composita globosa Weller	—	x
Composita sp.	x	—

FAUNAL TABLE LXV—Continued.

	Short Creek 4	Warsaw 5
<i>Pelecypods</i>		
Grammysia sp.	x	—
Edmondia subplana (Hall)	x	—
Paralleodon oblongus (Hall)	x	—
Conocardium meekianum Hall ?	x	—
Pteronites spergenensis Whitfield	x	—
Pteronites sp.	x	—
Schizodus sp.	x	—
Schizodus sp.	x	—
Cypricardella elliptica (Whitfield)	x	—
Cypricardella ? sp.	x	—
<i>Gastropods</i>		
Straparollus spergenensis (Hall)	x	—
Anomphalus rotuliformis Cumings ?	x	—
Holopea proutana Hall ?	x	—
Platyceras sp.	—	x
Bulimorpha elongata Hall ?	x	—
<i>Trilobites</i>		
Phillipsia ? sp.	x	—
Griffithides ? sp.	—	x

On Spring river near the bridge on the Waco-Lawton road northwest of Joplin, is an exposure of limestone that on the basis of incomplete fossil collections including *Productus magnus* is tentatively referred to the Warsaw. The section measured here is as follows:

(60.) Section on Spring River Near Bridge on Waco-Lawton Road. SE. 1-4, SW. 1-4, sec. 23, T. 29 N., R. 34 W.

	Thickness Feet. Inches.	
Osage group		
Boone formation		
Warsaw limestone		
4. Chert and limestone, the chert greatly predominating, limestone bluish, compact, no fossils observed	2	
3. Limestone, buff, fine-grained, compact, hard, thin-bedded, wavy stratification giving beds nodular appearance, non-fossiliferous	5	
2. Limestone, bluish, medium-grained, slightly crinoidal, rather thin-bedded, contains thin bands and nodules of dense flinty chert, upper part more massive, contains fossils, especially <i>Productus magnus</i> M. & W.	3	
1. Limestone, dark gray to buff, alternating layers of medium and fine-grained compact limestone, contains thin layers of flinty chert. Exposed	8	6
The fossils obtained at this place came almost entirely from Bed 2.		

LXVI. Fossils from Warsaw Limestone on Spring River Near Bridge on Waco-Lawton Road

<i>Brachiopods</i>	<i>Syringothyris</i> n. sp.
Orthotetes keokuk Hall	Pseudosyrinx ? sp.
Productus magnus M. & W.	Spiriferella neglecta (Hall) ?
Productus sp. cf. P. setigerus Hall	Reticularia pseudolineata (Hall)
Productus sp. cf. P. wortheni Hall	Athyris densa Hall & Clarke ?
Dielasma sp.	Composita sp. cf. trinuclea (Hall)
Spirifer subaequalis Hall ?	<i>Fish</i>
Spirifer washingtonensis Weller ?	Fish tooth
Spirifer keokuk Hall ?	

One-half mile west of the town of Ritchie in eastern Newton county, on the north side of Shoal creek and of the Frisco railroad tracks, an old quarry contains a good exposure of the Short Creek oolite and of the lower part of the overlying limestone. The section is as follows:

(61.) Section in Quarry West of Ritchey, Newton County

	Thickness Feet. Inches.	
Osage group		
Boone formation		
Warsaw limestone member		
3. Limestone, light blue, medium- to fine-grained, in part crinoidal and crystalline, in part very compact, dense, chert abundant in nodules, bands and zones, the upper 14 feet massive and somewhat less cherty than lower part	22	
Short Creek oolite member		
2. Limestone, white, weathering light creamy tan, oolitic, spherules very prominent on weathered surface, massive obliquely inclined joint planes prominent, contains fossils	6	6
Keokuk limestone		
1. Limestone, blue, medium to coarse-grained, crinoidal, crystalline, interbedded with finer grained hard, compact, limestone with subconchoidal fracture. Sparsely fossiliferous, containing <i>Orthotetes keokuk</i> Hall. Exposed.....	3	

LXVII. Fossils from the Short Creek Oolite, West of Ritchey, Newton County

<i>Brachiopods</i>	<i>Pseudosyrinx</i> ? sp.
Orthotetes keokuk (Hall)	Reticularia pseudolineata (Hall)
Chonetes illinoisensis Worthen	Cliothyridina hirsuta (Hall)
Productus ovatus Hall	Composita lewisensis Weller
Productus sp.	Composita globosa Weller
Rhipidomella dubia (Hall)	<i>Pelecypods</i>
Rhipidomella sp.	Edmondia sp.
Camarotoechia mutata (Hall)	Conocardium sp.
Allorhynchus macrum (Hall)	<i>Gastropods</i>
Tetracamera subcuneata (Hall)	Bellerophon sublaevis Hall
Spirifer bifurcatus Hall	Bembexia n. sp.
Spirifer keokuk Hall	

From the Short Creek member in the vicinity of Neosho the following fossils were obtained:

LXVIII. Fossils from the Short Creek Oolite at Neosho, Newton County

Brachiopods

Orthotetes keokuk (Hall)
Rhipidomella dubia (Hall)
Camarotoechia mutata (Hall)
Tetracamera subcuneata (Hall)
Brachythyris subcardiformis (Hall)

Syringothyris sp.
Cliothyridina hirsuta (Hall)
Composita globosa Weller ?

Trilobite

Griffithides bufo M. & W.

In the vicinity of Carthage, county seat of Jasper county, are several building stone quarries which afford good opportunity to study the beds of Warsaw age. Fossil collections are somewhat less readily secured than in ordinary quarries for the rock is generally cut by channeling machines into slabs and blocks which only show cross-sections of fossils. It is particularly difficult to make detailed collections by zones. However, the fossils obtained indicate that the well known Carthage stone is to be classed as Warsaw. A typical section is that measured at the Gill and Son quarry northwest of the city.

(62.) Section of Warsaw Limestone at Gill & Son Quarry, Northwest of Carthage, Jasper County

	Thickness Feet. Inches.
Osage group	
Boone formation	
Warsaw limestone member	
8. Limestone, light gray to bluish, medium-grained, crystalline, in beds 1-2 feet thick, chert, very irregularly distributed in nodules and thin bands, stylolites present.	7
7. Chert with interbedded fine- to medium-grained blue limestone. The chert is marked by an uneven distribution of bluish flinty material through siliceous limestone, beds thin, general appearance unlike typical Burlington chert.	1-1 ½
6. Limestone like 8 but showing a distinct interbanding of coarser and finer texture, stylolites common. In quarry face two massive beds appear 2-3 feet above and 4-5 feet below, a horizon of chert nodules occurring between the beds.	7-7 ½
5. Chert and limestone like 7.	1-1 ¼
4. Limestone, light bluish to bluish gray, medium-grained, very massive, stylolites common, fossiliferous, containing especially large-stemmed crinoids, <i>Pustula</i> sp., <i>Rhipidomella dubia</i> (Hall) and <i>Archimedes owenanus</i> Hall.	5
3. Chert and limestone like 7.	½-1
2. Limestone, bluish gray, medium-grained, hard, uniform, massive, stylolites common, non-cherty; this is the chief building stone. Contains <i>Archimedes owenanus</i> Hall, <i>Pustula alternata</i> (N. & P.), <i>Rhipidomella dubia</i> (Hall), <i>Reticularia pseudolineata</i> (Hall), <i>Spirifer lateralis</i> Hall and other characteristic Warsaw fossils.	25
1. Chert and limestone interbedded, similar to 7. Exposed	4

Fossils collected from this quarry come mainly from Bed 2, but as the cutting of the limestone makes it almost impossible to obtain fossils from the rock in place, it was expedient to gather

specimens from quarried slabs and irregular fragments. The following list, therefore, represents an unseparated collection, mainly from Beds 2 and 4:

LXIX. Fossils from the Warsaw Limestone at Gill & Son Quarry, Northwest of Carthage

Corals

- Triplophyllum dalei (E. & H.)
- Amplexus fragilis White & St. John ?
- Amplexus sp.
- Chaetetes ? sp.

Crinoid

- Actinocrinus sp.

Bryozoans

- Fistulipora sp.
- Tabulipora sp.
- Fenestella serratula Hall
- Fenestella serratula var. quadrata Cummings ?
- Fenestella multispinosa Ulrich
- Fenestella sp.
- Fenestella sp.
- Ptilopora prouti Hall
- Archimedes owenanus Hall
- Archimedes grandis Ulrich
- Cystodictya lineata Ulrich
- Cyclopora sp.

Brachiopods

- Schellwienella ? sp.
- Orthotetes keokuk (Hall)
- Productus setigerus Hall ?
- Productus magnus M. & W.
- Productus wortheni Hall
- Productus mesialis Hall

- Productus sp.
- Pustula alternata (N. & P.)
- Pustula n. sp.
- Rhipidomella dubia (Hall)
- Camarotoechia mutata (Hall)
- Spirifer rostellatus Hall ?
- Spirifer keokuk Hall
- Spirifer lateralis Hall
- Spirifer washingtonensis Weller
- Spirifer sp.
- Spirifer sp.
- Spirifer sp.
- Syringothyris ? sp.
- Reticularia pseudolineata (Hall)
- Composita globosa Weller ?

Pelecypods

- Cardiomorpha ? sp.
- Myalina keokuk Worthen
- Aviculopecten sp. cf. A. varsoviensis Worthen

Gastropods

- Platyceras paralum W. & W.
- Platyceras sp.

Pteropod

- Conularia subcarbonaria M. & W. ?

Trilobite

- Griffithides sp.

A good section of the Warsaw limestone showing 39 feet of beds corresponding essentially to those described in the Gill quarry was studied a short distance west of the Frisco depot at Carthage. At one place in this exposure the stratified limestone is interrupted by a dike-like fill of slightly different crystalline limestone containing broken chert promiscuously scattered through it. The contact with bedded limestone is distinct, especially where argillaceous matter with lamination slightly concave upward occurs in the fill. The fill does not extend to the top of the exposed rock face but doubtless reaches back some distance into the strata. The evidence suggests solution of the limestone followed by filling in later Mississippian time. Fossils collected from the stratified limestone are shown in the following list:

LXX. Fossils from the Warsaw Limestone in Quarry of the Spring River White Lime Company, West of the St. Louis & San Francisco Depot, Carthage, Jasper County

Corals

Zaphrentis sp.
Triplophyllum dalei (E. & H.) ?
Amplexus fragilis White & St. John
Amplexus sp.

Bryozoans

Fistulipora ? sp.
Leioclema punctatum (Hall)
Fenestella limitaris Ulrich ?
Fenestella tenax Ulrich ?
Fenestella multispinosa Ulrich ?
Fenestella triserialis Ulrich ?
Fenestella serratula Ulrich
Fenestella sp.
Fenestella sp.
Hemitrypa sp.
Archimedes grandis Ulrich
Archimedes owenanus Hall
Cystodictya lineata Ulrich
Cyclopora sp.
Worthenopora spinosa Ulrich

Brachiopods

Orthotetes keokuk (Hall)
Chonetes illinoisensis Worthen
Productus wortheni Hall
Productus sp.
Productus sp.
Productus setigerus Hall
Pustula alternata (N. & P.)

Pustula sp.
Pustula sp.
Rhipidomella dubia (Hall)
Rhipidomella sp.
Schizophoria sp.
Camarotoechia mutata (Hall)
Cranaena sp.
Dielasma sp.
Spirifer keokuk Hall
Spirifer lateralis Hall
Spirifer washingtonensis Weller
Spirifer sp.
Spirifer sp.
Brachythyris subcardiformis (Hall) ?
Brachythyris suborbicularis (Hall)
Syringothyris ? sp.
Pseudosyrinx ? sp.
Reticularia pseudolineata (Hall)
Athyris lamellosa (L'Eveille) ?
Cliothyridina sp.
Composita globosa Weller
Composita trinuclea (Hall) ?

Pelecypods

Myalina keokuk Worthen
Aviculopecten sp.
Platyceras paralum W. & W.
Platyceras sp.

Fish

Fish tooth

The description of the Warsaw rocks in Missouri which has been offered and the report on the fossils found in them suffice to show essential conditions. The Warsaw is widespread, probably underlying much of the northern part of the state and forming an important part of the exposed Mississippian beds in southwestern Missouri and adjoining parts of Arkansas, Oklahoma and Kansas.

The following comparison of the specifically identified fossils in the Warsaw and Keokuk formations of Iowa and Missouri, according to the list of Van Tuyl⁵⁹ and the writer, is of interest:

LXXI. General Comparative Faunal Table of the Keokuk and Warsaw formations in Missouri and in the Type Region of Southeastern Iowa and Western Illinois

	Keokuk		Warsaw	
	Mo.	Ia.-Ill.	Mo.	Ia.-Ill.
<i>Corals</i>				
<i>Zaphrentis varsoviensis</i> Worthen.....	cf	x	x	—
<i>Zaphrentis casedayi</i> Milne-Edwards.....	—	—	—	x
<i>Zaphrentis spergenensis</i> Worthen.....	—	—	—	x
<i>Triplophyllum dalei</i> (E. & H.).....	x	x	x	x
<i>Triplophyllum pellaensis</i> (Worthen).....	—	—	—	x
<i>Monilopora beecheri</i> Grabau.....	?	x	x	x
<i>Palaeacis obtusus</i> (M. & W.).....	x	x	—	—
<i>Homalophyllum calceolum</i> (White).....	x	—	—	—
<i>Amplexus fragilis</i> W. & St. J.....	x	—	x	—
<i>Crinoids</i>				
<i>Actinocrinus pernodosus</i> Hall.....	—	x	—	x
<i>Actinocrinus lowei</i> Hall.....	—	x	—	—
<i>Macrocrinus lagunculus</i> (Hall).....	—	x	—	—
<i>Macrocrinus verneuillianus</i> (Shumard).....	?	—	—	—
<i>Uperocrinus nashvillae</i> (Troost).....	—	x	—	x
<i>Agaricocrinus americanus</i> (Roemer).....	—	x	—	—
<i>Agaricocrinus americanus tuberosus</i> Hall.....	—	x	—	x
<i>Agaricocrinus wortheni</i> Hall.....	—	x	—	x
<i>Dorycrinus mississippiensis</i> Roemer.....	—	x	—	x
<i>Dizygocrinus biturbinatus</i> (Hall).....	—	x	—	x
<i>Eutrochocrinus planodiscus</i> (Hall).....	—	x	—	x
<i>Barycrinus spurius</i> (Hall).....	—	x	—	x
<i>Barycrinus magister</i> (Hall).....	—	x	—	—
<i>Barycrinus tumidus</i> (Hall).....	—	x	—	x
<i>Barycrinus stellatus</i> (Hall).....	—	x	—	x
<i>Barycrinus boonvillensis</i> Miller.....	—	—	x	—
<i>Batocrinus sampsoni</i> M. & G.....	—	—	?	—
<i>Synbathocrinus blairi</i> Miller.....	—	—	?	—
<i>Synbathocrinus swallowi</i> Hall.....	—	—	—	x
<i>Parichthyocrinus meeki</i> (Hall).....	—	x	—	—
<i>Platycrinus saffordi</i> Hall.....	—	x	—	—
<i>Blastoids</i>				
<i>Schizoblastus granulosus</i> (M. & W.).....	—	—	—	x
<i>Pentremites conoideus</i> Hall.....	—	—	x	x
<i>Echinoids</i>				
<i>Pholidocidaris irregularis</i> (M. & W.).....	—	—	—	x
<i>Archeocidaris keokuk</i> Hall.....	—	—	—	x
<i>Bryozoans</i>				
<i>Leioclema gracillimum</i> Ulrich.....	—	x	—	—
<i>Leioclema punctatum</i> (Hall).....	?	x	x	x
<i>Leioclema foliatum</i> Ulrich.....	—	—	—	x
<i>Fistulipora spergenense</i> Rominger.....	—	?	—	—
<i>Fenestella serratula</i> Ulrich.....	x	x	x	x
<i>Fenestella serratula quadrata</i> Cumings.....	x	—	x	—

FAUNAL TABLE LXXI—Continued.

	Keokuk		Warsaw	
	Mo.	Ia.-Ill.	Mo.	Ia.-Ill.
<i>Bryozoans—Cont'd</i>				
<i>Fenestella multispinosa</i> Ulrich.....	x	x	x	x
<i>Fenestella limitaris</i> Ulrich.....	—	x	x	x
<i>Fenestella exigua</i> Ulrich.....	x	—	x	x
<i>Fenestella tenax</i> Ulrich.....	x	x	x	x
<i>Fenestella compressa</i> Ulrich.....	x	x	x	x
<i>Fenestella compressa nododorsalis</i> Ulrich.....	x	x	—	—
<i>Fenestella compressa elongata</i> Cumings.....	x	—	x	—
<i>Fenestella funicula</i> Ulrich.....	—	—	x	x
<i>Fenestella elevatipora</i> Ulrich.....	—	—	x	—
<i>Fenestella cingulata</i> Ulrich.....	?	x	x	—
<i>Fenestella rudis</i> Ulrich.....	—	x	—	x
<i>Fenestella triserialis</i> Ulrich.....	?	x	x	x
<i>Fenestella regalis</i> Ulrich.....	x	—	x	—
<i>Polypora burlingtonensis</i> Ulrich.....	—	x	—	—
<i>Polypora halliana</i> Prout.....	—	x	?	—
<i>Polypora varsoviensis</i> Prout.....	?	x	x	x
<i>Polypora biseriata</i> Ulrich.....	—	—	—	x
<i>Polypora simulatrix</i> Ulrich.....	x	x	x	—
<i>Polypora retrorsa</i> Ulrich.....	—	x	x	x
<i>Polypora spininodata</i> Ulrich.....	—	—	x	x
<i>Polypora maccoyana</i> Ulrich.....	x	x	—	—
<i>Polypora striata</i> Cumings.....	—	x	?	—
<i>Polypora gracilis</i> Prout.....	—	—	—	x
<i>Hemitrypa aspera</i> Ulrich.....	—	—	—	x
<i>Hemitrypa pateriformis</i> Ulrich.....	x	x	?	x
<i>Hemitrypa proutana</i> Ulrich.....	—	x	x	x
<i>Hemitrypa proutana nododorsalis</i> Ulrich.....	—	—	—	x
<i>Hemitrypa perstriata</i> Ulrich.....	—	x	—	x
<i>Hemitrypa nodosa</i> Ulrich.....	—	—	—	x
<i>Fenestralia sancti-ludovici</i> Prout.....	—	—	x	x
<i>Archimedes owenanus</i> Hall.....	x	x	x	x
<i>Archimedes grandis</i> Ulrich.....	—	—	x	—
<i>Archimedes wortheni</i> Hall.....	—	—	x	x
<i>Ptilopora valida</i> Ulrich.....	—	x	—	x
<i>Ptilopora prouti</i> Hall.....	—	—	x	x
<i>Pinnatopora conferta</i> Ulrich.....	—	—	—	x
<i>Taeniodictya ramulosa</i> Ulrich.....	?	x	—	x
<i>Phractopora trifolia</i> (Rominger).....	x	x	—	x
<i>Proutella discoidea</i> (Prout).....	—	x	x	—
<i>Stictoporella basalis</i> Ulrich.....	x	—	—	—
<i>Glyptopora keyserlingi</i> (Prout).....	x	x	—	x
<i>Glyptopora elegans</i> (Prout).....	—	—	—	x
<i>Glyptopora michelinia</i> (Prout).....	—	—	—	x
<i>Glyptopora plumosa</i> (Prout).....	—	—	—	x
<i>Glyptopora sagenella</i> (Prout).....	—	—	—	x

FAUNAL TABLE LXXI—Continued.

	Keokuk		Warsaw	
	Mo.	Ia.-Ill.	Mo.	Ia.-Ill.
<i>Bryozoans—Cont'd</i>				
<i>Glyptopora sagenella calyculosa</i> Ulrich.....	—	—	—	x
<i>Cyclopora fungia</i> Prout.....	—	—	—	x
<i>Rhombopora attenuata</i> Ulrich.....	x	x	x	x
<i>Rhombopora dichotoma</i> Ulrich.....	—	x	—	—
<i>Rhombopora varians</i> Ulrich.....	x	x	x	x
<i>Rhombopora bedfordensis</i> Cumings.....	—	—	x	—
<i>Rhombopora</i> ? <i>asperula</i> Ulrich.....	—	x	x	—
<i>Bactropora simplex</i> Ulrich.....	—	x	—	x
<i>Acanthoclema confluens</i> Ulrich.....	—	x	—	—
<i>Cystodictya lineata</i> Ulrich.....	x	x	x	x
<i>Cystodictya lineata major</i> Ulrich.....	x	—	x	—
<i>Cystodictya pustulosa</i> Ulrich.....	—	—	x	x
<i>Cystodictya nitida</i> Ulrich.....	—	—	—	x
<i>Cystodictya americana</i> Ulrich.....	—	—	—	x
<i>Worthenopora spinosa</i> Ulrich.....	x	x	x	x
<i>Worthenopora spatulata</i> (Prout).....	x	—	—	x
<i>Streblotrypa major</i> Ulrich.....	—	x	—	—
<i>Streblotrypa radialis</i> Ulrich.....	—	x	—	x
<i>Brachiopods</i>				
<i>Lingula varsoviensis</i> Worthen.....	—	—	—	x
<i>Orthotetes keokuk</i> (Hall).....	x	x	x	?
<i>Streptorhynchus ruginosum</i> (Hall & Clarke).....	—	—	x	x
<i>Chonetes shumardanus</i> De Koninck.....	—	x	—	—
<i>Chonetes illinoisensis</i> Worthen.....	x	—	x	—
<i>Productus setigerus</i> Hall.....	x	x	x	x
<i>Productus wortheni</i> Hall.....	x	?	x	—
<i>Productus ovatus</i> Hall.....	x	x	x	x
<i>Productus mesialis</i> Hall.....	x	x	x	—
<i>Productus magnus</i> M. & W.....	?	—	x	—
<i>Productus viminalis</i> White.....	—	x	—	—
<i>Productus crawfordsvillensis</i> Weller.....	?	—	—	—
<i>Pustula alternata</i> (N. & P.).....	x	x	x	x
<i>Pustula biseriata</i> (Hall).....	x	x	x	x
<i>Pustula indianensis</i> (Hall).....	—	—	x	x
<i>Rhipidomella burlingtonensis</i> (Hall).....	x	—	—	—
<i>Rhipidomella dubia</i> (Hall).....	x	x	x	x
<i>Schizophoria swallowi</i> (Hall).....	?	—	—	—
<i>Camarotoechia tuta</i> (Miller).....	x	—	—	—
<i>Camarotoechia mutata</i> (Hall).....	?	x	x	x
<i>Camarotoechia grosvenori</i> (Hall).....	—	—	x	—
<i>Tetracamera subcuneata</i> (Hall).....	x	x	x	x
<i>Tetracamera subtrigona</i> (M. & W.).....	x	x	—	—
<i>Rhynchopora beecheri</i> (Greger).....	—	x	—	—
<i>Cranaena sulcata</i> Weller.....	—	?	—	x
<i>Cranaena globosa</i> Weller.....	x	—	—	—

FAUNAL TABLE LXXI—Continued.

	Keokuk		Warsaw	
	Mo.	Ia.-Ill.	Mo.	Ia.-Ill.
<i>Brachiopods—Cont'd</i>				
<i>Dielasma sinuatum</i> Weller.....	x	x	—	—
<i>Dielasma arkansanum</i> Weller.....	—	—	?	—
<i>Dielasma inflatum</i> Weller.....	—	—	?	—
<i>Dielasma chouteauense</i> Weller.....	?	—	—	—
<i>Girtyella indianensis</i> (Girty).....	—	—	—	x
<i>Girtyella turgida</i> (Hall).....	—	—	—	x
<i>Allorhynchus macrum</i> (Hall).....	—	—	x	—
<i>Delthyris similis</i> Weller.....	—	?	—	—
<i>Spiriferina norwoodana</i> (Hall).....	—	—	—	x
<i>Spirifer keokuk</i> Hall.....	x	x	x	x
<i>Spirifer logani</i> Hall.....	x	x	—	—
<i>Spirifer rostellatus</i> Hall.....	x	x	x	x
<i>Spirifer tenuicostatus</i> Hall.....	x	x	x	x
<i>Spirifer grimesi</i> Hall.....	x	x	—	—
<i>Spirifer washingtonensis</i> Weller.....	—	—	x	—
<i>Spirifer subaequalis</i> Hall.....	—	x	x	—
<i>Spirifer bifurcatus</i> Hall.....	—	—	x	x
<i>Spirifer lateralis</i> Hall.....	—	—	x	—
<i>Spirifer incertus</i> Hall.....	—	x	—	—
<i>Brachythyris suborbicularis</i> (Hall).....	x	x	x	x
<i>Brachythyris subcardiformis</i> (Hall).....	—	—	?	x
<i>Pseudosyrinx keokuk</i> Weller.....	x	x	?	—
<i>Syringothyris subcuspidatus</i> (Hall).....	—	x	—	x
<i>Syringothyris textus</i> (Hall).....	—	—	—	x
<i>Spiriferella plena</i> (Hall).....	x	—	—	—
<i>Spiriferella neglecta</i> (Hall).....	x	x	?	x
<i>Eumetria verneuilliana</i> (Hall).....	x	x	x	x
<i>Reticularia pseudolineata</i> (Hall).....	x	x	x	x
<i>Reticularia setigera</i> (Hall).....	—	x	—	x
<i>Athyris lamellosa</i> (L'Eveille).....	x	x	—	—
<i>Cliothyridina obmaxima</i> (Hall).....	x	x	—	x
<i>Cliothyridina hirsuta</i> (Hall).....	—	—	x	—
<i>Cliothyridina parvirostra</i> (M. & W.).....	x	x	x	x
<i>Cliothyridina incrassata</i> (Hall).....	—	x	—	—
<i>Composita globosa</i> Weller.....	x	x	x	x
<i>Composita pentagona</i> Weller.....	—	x	—	—
<i>Composita trinuclea</i> (Hall).....	—	x	?	x
<i>Composita lewisensis</i> Weller.....	—	—	x	—
<i>Pelecypods</i>				
<i>Myalina keokuk</i> Worthen.....	x	x	x	—
<i>Edmondia varsoviensis</i> Worthen.....	—	—	—	x
<i>Edmondia subplana</i> (Hall).....	—	—	x	—
<i>Edmondia illinoisensis</i> Worthen.....	—	—	—	x
<i>Parallelodon oblongus</i> (Hall).....	—	—	x	—
<i>Cypricardina indianensis</i> (Hall).....	—	—	—	?

FAUNAL TABLE LXXI—Continued.

	Keokuk		Warsaw	
	Mo.	Ia.-Ill.	Mo.	Ia.-Ill.
<i>Pelecypods—Cont'd</i>				
<i>Cypricardella elliptica</i> (Whitfield).....	—	—	x	—
<i>Lithophagus illinoisensis</i> Worthen.....	—	x	x	x
<i>Conocardium meekianum</i> Hall.....	—	—	?	—
<i>Pteronites spergenense</i> Whitfield.....	—	—	x	—
<i>Pinna subspatulata</i> Worthen.....	x	—	—	—
<i>Aviculopecten colletti</i> Worthen.....	x	—	—	—
<i>Aviculopecten niotensis</i> Worthen.....	?	—	x	—
<i>Gastropods</i>				
<i>Bellerophon sublaevis</i> Hall.....	—	—	x	—
<i>Straparollus spergenensis</i> (Hall).....	—	—	x	—
<i>Strophostylus</i> ? <i>carleyana</i> (Hall).....	—	—	—	?
<i>Anomphalus rotuliformis</i> Cumings.....	—	—	?	—
<i>Holopea proutana</i> Hall.....	—	—	?	x
<i>Bulimorpha elongata</i> Hall.....	—	—	?	—
<i>Platyceras paraliun</i> W. & W.....	x	—	x	—
<i>Platyceras fissurella</i> Hall.....	—	x	—	—
<i>Platyceras equilaterale</i> Hall.....	?	x	—	x
<i>Orthonychia pabulocrinus</i> (Owen).....	?	x	—	—
<i>Orthonychia cornuiformis</i> (Winchell).....	x	—	—	—
<i>Lepetopsis capulus</i> (Hall).....	x	—	—	—
<i>Pteropods</i>				
<i>Conularia missouriensis</i> Swallow.....	—	cf	x	—
<i>Conularia subcarbonaria</i> M. & W.....	—	—	?	—
<i>Trilobites</i>				
<i>Griffithides portlocki</i> M. & W.....	x	—	—	—
<i>Griffithides bufo</i> M. & W.....	x	—	?	—

This table gives clear indication of the relations faunally between the Keokuk and Warsaw of Missouri, as defined by the writer, and corresponding formations in Iowa and Illinois. It also shows in both regions the large number of common species in the rocks assigned to these two stratigraphic divisions. Possible errors due to inexact identification of species and incompleteness of faunal data may render the similarities less in the table than is actually the case. For example, few Keokuk or Warsaw crinoids were collected by the writer in Missouri although in places they are known to be fairly common, and it is possible that the boundaries of the formations as drawn in Missouri do not correspond precisely to those in the type region. The geode-bearing shale which marks the lower Warsaw in western Illinois and southeastern Iowa is a local deposit not

known in Missouri, but in central and northeastern Missouri the Warsaw contains noticeably more shale than the subjacent Keokuk. The apparent unconformity at the base of the Short Creek oolite in southwestern Missouri separates beds which have respectively the faunal characters of Keokuk and Warsaw. Without undertaking a detailed analysis of the evidence, the conclusion may be advanced that rocks of Keokuk and Warsaw age are well represented in Missouri and that they are lithologically, faunally and stratigraphically closely related. The geographic distribution of the Warsaw corresponds to that of the Keokuk much more closely than to that of the Spergen or St. Louis. The Warsaw is fairly thick and widespread in southwestern Missouri and adjacent states where the older Osage beds are well developed, but nowhere in this region are typical Spergen or St. Louis strata known, nor is there reason to believe they were deposited here.

Correlation. The Warsaw limestone in Missouri corresponds closely to the type development of the formation that is seen in western Illinois and southeastern Iowa. With little doubt strata of this age are continuous under cover from Warsaw to southwestern Missouri, Kansas, Oklahoma and northern Arkansas. The Warsaw is found in Indiana (Harrodsburg limestone), Kentucky, Tennessee and Alabama. It has been identified tentatively in West Virginia and Virginia. The formation is thus widespread, and throughout the region in which it has been distinguished there are rather constant faunal and lithologic characters.

SUMMARY

Early Osage formations. In most places rocks of the Osage group are separated from the Kinderhook beds by a disconformity. In the vicinity of St. Louis the initial Osage deposit is called the Fern Glen formation, about 40 feet thick. It is marked by its reddish and greenish color, partial shaly character and its fauna. The Fern Glen extends southeastward as far as Ste. Genevieve County, Missouri, and an unknown distance beneath younger rocks in Illinois. Originally it may have been connected with similar deposits in northern Arkansas and southwestern Missouri that are called St. Joe limestone. Northward the Fern Glen grades laterally into yellowish or buff, soft, mainly non-crinoidal limestone in the lower part and crinoidal Lower Burlington limestone in the upper part. The yellowish or buff

limestone is regarded as equivalent to the Sedalia limestone of central Missouri.

The Sedalia limestone is a massive, fine-grained, light bluish gray rock that weathers creamy yellow or buff. Its average thickness is about 35 feet but in many places it is much thinner. In lithologic character and fauna it is readily distinguished from the underlying Chouteau limestone and its stratigraphic relations indicate that it should be assigned to the Osage group. In earlier reports this "silico-magnesian" limestone was designated "Upper Chouteau;" as used in this paper the term Chouteau refers to the "Lower Chouteau" of previous authors. The Sedalia is typically developed in the central Missouri region but is distinguished also in many parts of northeastern Missouri. It is believed to correspond to Bed 7 of the Kinderhook as previously defined at Burlington, Iowa, the Wassonville limestone, part of the LeGrand beds and other Iowa formations that have been referred to the upper Kinderhook.

In part of southwestern Missouri the Pierson limestone, a buff, fine-grained magnesian rock, appears to correspond more or less exactly to the Sedalia which it resembles most closely. It ranges in thickness to about 30 feet and is typically found in Greene county. It extends northward from this region, probably being continuous with the Sedalia, but southward it disappears.

The initial Osage deposit in most of southwestern Missouri and in adjoining portions of neighboring states is the St. Joe limestone, here classed as basal member of the Boone formation. Like the Fern Glen, which it most closely resembles, this limestone is rather thin-bedded, contains shaly material between the limestone layers and shows reddish and greenish colors. The occurrence of several index fossils in the St. Joe, Fern Glen and other early Osage deposits supports the correlation between them. The thickness of the St. Joe limestone ranges from about 25 feet to 40 feet. Strata belonging to this member are distinguished from the overlying dark, very cherty Reeds Spring limestone by general absence of chert and by other lithologic characters.

The early Osage formations in Missouri are marked by faunal characteristics that serve to separate them from Kinderhook deposits on the one hand and from Burlington and later formations on the other. However, relationships indicate fairly clearly that they belong with the succeeding rather than the preceding beds. They are correlated with sediments in the Lake Valley region of New Mexico, the New Providence shale of

Indiana, western Kentucky and Tennessee, the Logan and Cuyahoga formations of Ohio, eastern Kentucky and western Pennsylvanian, and at least part of the Pocono formation of the Appalachian region.

Burlington limestone. The Burlington limestone is a fairly widespread, light colored, massive crinoidal and cherty limestone, rather uniform in lithologic character. Typically the rock is coarse-grained; much of the rock is white or light bluish or yellowish gray, but some of the beds are dark brown. In part the formation consists of nearly pure calcium carbonate. The average thickness of the Burlington is about 150 feet. Its fauna is large and distinctive, marked especially by a profusion of crinoids and brachiopods. The formation is divisible into lower and upper portions which are distinct faunally and which can generally be recognized on lithologic characters. The Burlington is typically developed in southeastern Iowa and adjacent parts of western Illinois and northeastern Missouri. In central Missouri and as far southwest as Greene and Dade counties the formation is practically the same as at Burlington.

In the southern part of southwestern Missouri, in Jasper, Lawrence and Stone counties and to the south, the only deposit of Burlington age is the Reeds Spring limestone member of the Boone formation. This limestone, which has an average thickness of 150 feet, is medium to fine-grained, very dense, rather dark blue or bluish gray and contains an abundance of very hard, dense chert. In some exposures the chert and limestone are nearly equal in amount, occurring in moderately thin alternating layers. The fauna of the Reeds Spring indicates that it is not younger than Lower Burlington and it may be, at least in part, of Fern Glen age. There is no Upper Burlington in this region.

The Lower Burlington is apparently equivalent to the lower part of the Fort Payne chert in Tennessee and Alabama, a formation which affords rather striking lithologic, as well as faunal similarity to the Reeds Spring limestone. It represents also a part of the New Providence shale, Logan-Cuyahoga, and Pocono formations of the east. On the other hand, the Upper Burlington is not known to be represented by deposits southeast of the Iowa-Missouri portion of the Mississippi valley. Formations of Burlington age are known in the far west (in the Madison-Redwall) but information concerning these deposits does not permit detailed comparison.

Keokuk limestone. The Keokuk limestone resembles the Burlington in general lithologic and faunal characters, but there are persistent distinctions that make them clearly recognizable in most localities, especially on faunal grounds. The Keokuk is generally more thinly bedded, slightly more shaly and bluer in color than the Burlington, and it is marked by the prominence of its bryozoans. The crinoidal fauna of the Keokuk is varied but it is mostly made up of species unknown in the Burlington beds. The average thickness of the Keokuk in the Missouri and Iowa area is about 70 feet.

In the portion of southwestern Missouri where the Osage beds are classed together under the name Boone formation, the Keokuk is represented by the Grand Falls chert member, about 35 feet thick, and a cherty limestone member, about 65 feet thick. The Grand Falls chert rests disconformably on the Reeds Spring limestone.

In Indiana and western Kentucky the Keokuk is represented by shale and sandstone (Kenwood, Rosewood, Holtsclaw) but farther south, in Tennessee and Alabama, rocks of this age consist of limestone and chert (main part of Fort Payne chert) similar to the cherty Boone formation of southwest Missouri.

Warsaw limestone. The Warsaw limestone shows affinity in lithology, fauna, distribution and general stratigraphic relations with formations of the Osage group. The formation is typically more shaly than the Keokuk or Burlington, but in southwestern Missouri it is represented by massive crystalline pure limestone that is locally non-cherty and makes excellent building and ornamental stone. At the base of the Warsaw of this region, separated from underlying limestone of Keokuk age by a slight disconformity, is a thin oolitic limestone (Short Creek oolite member of the Boone formation). The thickness of the Warsaw limestone in Missouri is not accurately known but it appears to range from less than 50 to about 100 feet. Outcrops of the Warsaw occur in northeastern, southeastern, central and southwestern Missouri, indicating that the formation is widespread; it is, however, largely concealed by overlapping younger formations.

Warsaw deposits occur in Indiana, Kentucky, Tennessee and Alabama, and are tentatively identified in West Virginia and Virginia. The westward extent of the Warsaw beneath the Pennsylvanian of Kansas and Oklahoma is unknown. Subsurface studies in south central Oklahoma indicate that the "Mississippi lime" of that region includes no beds as old as Warsaw.

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PALEONTOLOGY

BRACHIOPODA

Genus *Orbiculoidea* D'Orbigny*Orbiculoidea hardinensis* Moore, n. sp.

Plate XI, Figs. 1, 2, 5, 6.

Description—Shell rather small, subelliptical in outline. The dimensions of two pedicle valves, cotypes, are: width 3.5 mm. and 4 mm., length 4 mm. and 4.4 mm., of a brachial valve width 7.3 mm., length 8 mm.

Pedicle valve nearly flat, the pedicle opening situated excentrically in the line of the longer axis of the valve and extending from a point near the center of the valve about half the distance to the posterior margin. Its lateral margins are very sharply and abruptly elevated upon the internal surface of the valve forming a very sharp ridge which probably represents a corresponding depression on the external surface of the valve. The surface is marked by somewhat prominent concentric lines of growth and in well preserved examples exceedingly fine radiating lines are visible with a lens.

Brachial valve, depressed conical, the apex situated about one-fourth the length of the shell from the posterior margin and directed posteriorly. The surface is gently convex toward the anterior and lateral margins, distinctly concave toward the posterior margin. The surface is marked by closely crowded, fine, concentric lines of growth which becomes more pronounced toward the margins of the shell.

Remarks. This species is distinguished by its sharply defined pedicle fissure, very small size, and surface markings. In all the specimens observed the shell substance is nacreous.

Horizon—Base of Hannibal formation.

Locality—Godar Creek near bluff road, 2 miles north of Hardin, Calhoun County, Illinois, Walker Museum 32122, Moore Collection.

Genus *Chonetes* Fischer*Chonetes alatus*, Moore, n. sp.

Plate XI, Figs. 3, 4.

Description—Shell concavo-convex, the length about one-half the width, the hinge line not quite equalling the maximum width of the shell. The cardinal extremities are slightly rounded or nearly rectangular, the lateral margin sloping in a regular curve to the anterior. In the middle anterior portion of the shell, the margin is nearly straight for a short distance. The dimensions of two of the cotypes are: length 5.9 mm. and 9.1 mm., width 12 mm. and 16.5 mm., convexity 2 mm. and 3 mm.

Pedicle valve depressed convex, greatest convexity slightly posterior to the middle, compressed toward the cardinal extremities, the central portion of the valve appearing markedly elevated in some examples. A shallow, ill-defined sinus is observable in the anterior portion of the shell. Cardinal area not observed.

Brachial valve rather deeply concave, slightly flattened toward the cardinal extremities. The cardinal area is very narrow, the cardinal process is of moderate size.

The surface of both valves is marked by nearly regular, radiating plications of moderate size, about 3 occupying the space of 1 mm. They increase by bifurcation on the pedicle valve and by intercalation and bifurcation on the brachial valve. Toward the lateral margins, especially on the brachial valve, the plications become nearly

obsolete. In well preserved examples a series of irregularly spaced spines or elongate nodes is found on the plications. The costae are also crossed by very fine concentric lines but these are in most cases not observable.

Remarks—This species occurs rather abundantly in the Chonopectus sandstone and superjacent "Chonetes layer" at Burlington, Iowa, and at Kinderhook, Illinois. In its lengthened wings and relatively short length this species is very readily distinguished from any other described species of the Mississippian.

Horizon—Chonopectus sandstone (Hannibal formation) and Bed 3 ("Chonetes bed") Burlington.

Locality—Burlington, Iowa, Kinderhook, Illinois. Walker Museum 32123, Moore Collection.

Genus *Productus* Sowerby

The family *Productidae* includes a host of shells so related in various respects that classification offers difficulty. Various groupings have been suggested, that now in general use including: (a) *Chonetinae*, productids with the few anchoring spines restricted to the ventral cardinal margin, (b) *Productinae*, productids with the anchoring spines more or less abundant over the entire ventral and sometimes the dorsal valve, and (c) *Strophalosiinae*, productids anchored or cemented to foreign objects by the spines or by most of the ventral shell. The first two of these group names were introduced by Waagen to include respectively, (a) productids possessing teeth on the pedicle valve, generally also a cardinal area, and (b) productids without teeth in the pedicle valve.

The genus *Productus*, which is peculiarly characteristic of the Carboniferous, is by far the most important among the *Productidae*. Its range in form and ornamentation is extreme, and the number of closely related varieties is so great that the number of species found in this country alone is unwieldy. A recent monographic study by Ivor Thomas* of the forms which in Great Britain have been included under the genus *Productus* is important. As defined by Davidson† *Productus* includes shells in which "the hinge-line is straight and strong, with or without teeth and sockets for the articulation of the valves." Though emphasizing the generally edentulous character of the Carboniferous *Productus*, Davidson included in that genus the Devonian productids which, because of their possession of cardinal teeth and an area, are commonly included under Hall's genus *Productella*. Thomas seems to recognize the generic character of *Productella*, but regarding it as a strictly Devonian genus, he does not include it in his revision of the Carboniferous *Producti*. Of seven genera (not including *Productella*) which Thomas recognizes in the former *Productus*, the following appear to be represented in American Mississippian strata.

Productus Sowerby (restricted)—Forms which are costate throughout all stages of growth. Sporadic spines, or groups or rows of spines, may appear on the costae (longitudinal ridges) or at intersection of the costae and ribs (transverse wrinkles), where the semireticulate feature is developed on the visceral part of the shell-surface. It is likely that more than one phyletic series is represented in this section. Genotype, *Anomiles productus* Martin.

Avonia Thomas—Forms which are spinose in the early stages but develop costae at a later period. These are undoubtedly in the catagenetic stages, and are represented by at least two series, one of which is geniculated, the other non-geniculated. Genotype, *Productus youngianus* Davidson.

Pustula Thomas—Forms which are essentially spinose in ornamentation. Among these are several series such as (a) those without geniculation and possessing concentric

*Ivor Thomas, The British Carboniferous *Producti*, Mem. Geol. Survey Great Britain, vol. 1, pt. 4, London, 1914.

†T. Davidson, The Carboniferous Brachiopoda, Mon. British Fossil Brachiopoda, vol. 2, pt. 5, London, 1858-1863.

bands or ribs, (b) without geniculation and clearly defined concentric ornamentation, and (c) geniculated forms. Genotype, *Producta pustulosa* Phillips.

These genera are founded chiefly on external features. In so far as these correspond to significant structural features of the organism, such as a well defined condition of the mantle depositing the shell, correlated with the racial advance or degeneracy of a group, the features selected by Thomas seem to be valid bases for the delimitation and construction of natural groups of related species. They have the immediate advantage, at any rate, that the generic relations of a given shell may be determined at once from external features without reference to often undeterminable internal characters. Girty* has reviewed these genera, listing the known American species and their distribution in the new genera. Though a large number of the forms formerly referred to *Productus* remain in that genus as restricted by Thomas, a considerable number of species may be referred to the new genera.

There remain certain considerations which must be given to the genus *Productella*. As defined by Hall** this genus includes "shells having the general form of *Productus*, but uniformly with a narrow area on each valve, a foramen or callosity on the ventral area, small teeth, and more or less distinct teeth-sockets." It is essentially different from *Productus* "in the constant presence of an area, hinge-teeth and sockets." In Great Britain no species referable to this genus appear to occur in the Carboniferous, but in this country a number of forms, such as the abundant and characteristic *Productella concentrica* of the Kinderhook are found. It may be observed that the surface features of these so-called *Productellas* is identical with the sculptural ornamentation with which Thomas characterizes the genus *Pustula*, namely the absence of radial costae and the more or less numerous spines. Thomas does not mention hinge teeth or the presence of a cardinal area in his descriptions of *Pustula* and it may be assumed that his specimens are edentulous and without an area. The distinguishing feature between *Pustula* and *Productella*, therefore, seems to be the presence or absence of these features. It is possible, as noted by Girty,† that when the internal characters of the species referred to *Pustula* are known, some will prove to belong to *Productella*, and on the other hand that species formerly classed as *Productella* will be shown to be edentulous, and therefore belonging to *Pustula*. In very few cases, even among Devonian forms, is it possible to distinguish satisfactorily the internal features on which *Productella* is founded, and in practice the recognition of the genus has depended on the general type of surface markings. Accordingly question arises as to the true position of the Mississippian non-costate spinose productids. There is no inherent reason for supposing the extinction of all of the primitive productids with teeth and a cardinal area at the beginning of the Mississippian, nor on the other hand is there evidence that the edentulous *Pustula* type of shells did not live before the Mississippian.

In this connection it is interesting to notice the typical Upper Devonian species *Productella hallana*. Recent careful study by Dr. A. O. Thomas of a considerable collection of these shells in a beautifully preserved condition has shown that this species not only possessed no cardinal area but was absolutely lacking in cardinal teeth or sockets. Since the genus *Pustula* is founded on features that are very readily observed, it seems best to the writer to refer to *Pustula* all Mississippian forms which conform entirely to the definition of that genus and not definitely known to possess more or less developed hinge teeth and an area. Later investigation may define accurately the generic relationships of these *Productella*-like *Pustulas*, but since at least as late as Spargen time (*Productus indianensis*) they are found in association with the typical *Pustulas* (*Pustula*

*G. H. Girty, Chapter on Invertebrate Paleontology, in *The Stratigraphy of the Pennsylvanian Series of Missouri*, by Hinds and Greene: Mo. Bur. Geol. and Mines, (2), vol. XIII, 344-350 (1915).

**James Hall, *New York Geol. Survey, Pal.*, vol. IV, Pt. 1, 153, (1867).

†Loc. cit., p. 349.

alternata type), it seems best to regard the sparsely spined forms with the thickly spined and include all under the name *Pustula*. They are so regarded in the present report.

Only one of the Mississippian species commonly considered as *Productella* in the literature, seems to show the presence of hinge teeth, and even in this case they are somewhat doubtful. Illustrations of *Productella pyxidata* (Hall) indicate a narrow cardinal area and small hinge teeth and it should, therefore, be retained as a Carboniferous member of the genus *Productella*.^{*} A drawing of the interior of the brachial valve of this species,[†] however, shows ridges very strongly suggestive of Thomas' genus *Overtonia*. But one specimen of *Overtonia* is described and its validity as a genus is not proved, but if *Overtonia* is recognized, *P. pyxidata* in America, more nearly than any other known form, is suggestive of it. The brachial ridges of *P. pyxidata* begin at the posterior end of the median septum and as in the genotype of *Overtonia* diverge from it at an angle of approximately 45 degrees. However, the double ridge which is noted by Thomas in *Overtonia* is not apparent on specimens of *P. pyxidata* which were examined; and the shape of the impressions is not exactly similar. The distal loops in *P. pyxidata* swing very sharply toward the medial portion of the valve, and the median septum, unlike that of *Overtonia fimbriata* reaches forward to the mid-length of the shell. The presence of hinge teeth and a cardinal area is not mentioned in the case of *Overtonia*.

Productus sampsoni Weller.

Productus sampsoni Weller was established on a series of specimens found in the Sampson Collection at Walker Museum from the Chouteau limestone of Pettis County, Missouri, and a half dozen similar shells collected by Weller from the Fern Glen limestone near Kimmswick, Jefferson County, in southeastern Missouri. While these two groups are closely similar in size and general form examination of them shows a rather uniform distinction which may prove to be worthy of notice. The Chouteau limestone specimens are characteristically narrow with a pronounced prominence of the median portion of the pedicle valve, the hinge line distinctly narrower than the average width of the shell. The examples from the Fern Glen are broad, in a few instances broader than long, with the greatest width along the hinge line which may project beyond the sides of the shell as a well marked auriculation. A common shape is not unlike *Pustula* (*Productella*) *concentrica*. The costae of the Fern Glen forms appear to be slightly coarser than in the Chouteau limestone specimens, about 3 to 4 in 2 mm. in the former and 4 to 5 in 2 mm. in the latter where also the repeated bifurcation of the costae toward the anterior margin of the shell is more noteworthy.

P. sampsoni, as it occurs in the collections of the writer, is restricted to the Sedalia and Lower Burlington limestones and his specimens appear identical to those in the Sampson Collection. It seems probable therefore, that the cotypes of the species from the "Chouteau limestone" belong to the upper division, not to the lower, a conclusion which is strengthened by the lithologic character of the rock containing the specimens. *P. sampsoni* is one of the most abundant forms in the white chert fauna of the Lower Burlington at Osceola, Missouri.

Productus arcuatus Hall

The small and distinctive type of *Productus* referred to the species *P. arcuatus* Hall which occurs commonly in the Chouteau of central Missouri and in Bed 6 at Burlington, Iowa, appears to be restricted essentially to that horizon. Species of *Productus* are however found in higher beds, which closely resemble *P. arcuatus* but are essentially distinct from that form. In the Lower Burlington chert at Osceola a number of perfect specimens of this closely related type are found which show the nearly vertical lateral

^{*}James Hall and John M. Clarke, New York Geol. Survey, Pal., vol. VIII, Pt. 1, pl. XVII A, fig. 14, (1892).

[†]Idem, pl. IVII, fig. 34.

slopes, moderate short hinge line and small, nearly vertical cardinal auriculations of *P. arcuatus* but are notably larger. They have about the same size and spacing of the costae observed in *P. arcuatus*. However, the concentric wrinkles which with the costae (very poorly developed in *P. arcuatus*) make a semireticulate pattern, are here well defined, particularly on the brachial valve. In the development of a slight but well defined mesial sinus which is entirely absent in *P. arcuatus*, the slightly fasciculate arrangement of the costae and the general outline and size of the shell, the white chert species suggests *P. fernglenensis* Weller. A small example of *P. fernglenensis* from the Fern Glen of southern Missouri appears to be identical with the forms under discussion, and unless they represent a distinct species intermediate in character they should be referred to *P. fernglenensis*.

Comparison of the white chert specimens with *P. arcuatus*, *P. fernglenensis*, and *P. burlingtonensis* suggests besides a close resemblance of general form a genetic relationship between these species. On account of the poor definition of the costae in *P. arcuatus* especially in the umbonal region, this shell has been referred by Girty to Thomas' genus *Avonia*. If Girty's determination is correct and if *Avonia* is not a random grouping of forms possessing an external resemblance but of diverse genetic relations, the connection suggested between *P. arcuatus* and the succeeding species mentioned would not be possible. Well preserved specimens from the type locality and the plesiotypes in the collection at Walker Museum show the costae very well defined in the umbonal region even close to the beak and the writer believes the species should be retained in the genus *Productus* as restricted.

P. fernglenensis is separable on morphologic and stratigraphic grounds from *P. burlingtonensis*, but may be regarded as a transitional type between *P. arcuatus* and *P. burlingtonensis*. *P. burlingtonensis* as restricted, is abundant in the Upper Burlington but is not known below this horizon. A closely related species is *P. sedaliensis* Weller of the Chouteau limestone. This is a shell comparable in size with *P. fernglenensis* and *P. burlingtonensis* but distinguished from them by its flaring lateral slopes and anterior margin. Weller also notes the interrupted intercostal furrows toward the beak of *P. sedaliensis* and the absence of any mesial sinus. In the greater coarseness of its costae and concentric furrows and in its general form *P. sedaliensis* suggests the larger productids of the Burlington such as *P. viminalis* to which it may, indeed, be genetically related.

Productus calhounensis Moore n. sp.

Plate X, Figs. 1-6

Description—Shell of medium size, longer than wide, the greatest width toward the anterior portion of the shell. The dimensions of the holotype are as follows: length from hinge-line to anterior margin 23.4 mm., length from umbonal region to anterior margin 32.5 mm. greatest width 31 mm., length of hinge-line 20.1 mm.

Pedicle valve strongly convex in mature specimens, the umbonal rather broad and produced moderately beyond the hinge-line. The mesial portion of the valve is broadly flattened the surface curving abruptly on the lateral slopes. A slight shallow sinus is traceable nearly to the beak, in some cases marked by a slightly stronger median plication. The cardinal auriculations are rather small and compressed horizontally. The surface is marked by broad, ill-defined, flat radiating plications which though not well marked, are not discontinuous. In some specimens the anterior portion of the shell is nearly smooth. The posterior half of the valve is crossed by strong, concentric wrinkles which become most conspicuous toward the cardinal extremities. The entire surface of the valve is marked by minute corrugations irregularly parallel to the greater length of the shell, which may have borne small spines. This fine marking appears to be a characteristic feature of the species: Fine concentric lines of growth cross the longitudinal markings described.

Brachial valve gently concave throughout the visceral portion, the concavity becoming abruptly greater toward the anterior and lateral margins of the shell. The anterior portion of the valve is slightly elevated in a low, ill-defined, mesial fold. Radiating plications crossed by strong concentric wrinkles and fine growth lines are well marked.

Remarks—This species is distinguished from most other productids of the Kinderhook by the very low, poorly defined character of its plications, the minute corrugations and the general outlines of the shell. It is perhaps most closely related to *B. blairi* of the Chouteau but differs notably from that species in the continuity of its radiating plications and the absence of elongate nodes. It is also more extended anteriorly than that species. The most distinctive character of the species is the broad, depressed, ill-defined character of its plications.

Horizon—Chouteau limestone, Compton limestone, Kinderhook.

Localities—Dogtown Creek, Calhoun County, Illinois. Near Grafton, Jersey County, Illinois; Walker Museum 32118 (holotype), Moore Collection. Near Springfield, Greene County, Missouri; Walker Museum 8571, Weller Collection.

Productus newtonensis Moore n. sp.

Plate X, Figs. 12, 13

Description—Shell large, as wide or wider than long, the greatest width near the mid-length of the shell, hinge-line slightly shorter than the greatest width. The dimensions of a nearly complete specimen, though slightly crushed and of an uncrushed brachial valve is as follows: length from hinge-line to front margin 50 mm. and 38 mm., length from umbonal region to front margin 59 mm. and —, greatest width 60 mm. and 50 mm., length of hinge-line 49 mm. and 48 mm.

Pedicle valve somewhat gibbous, greatest curvature posterior to the middle of the valve, the umbonal region prominent, protuberant beyond the hinge-line, beak small and moderately incurved over the hinge-line. Beginning in the umbonal region and extending anteriorly across the mesial portion of the valve is a shallow sinus, which, though its lateral margins are ill-defined is very distinctly marked. The cardinal extremities are compressed to form well-differentiated auriculations. Surface marked by subangular, narrow radiating costae usually a little less than 1 mm. from center to center, about 12 occurring in a space of 10 mm. on the anterior portion of the shell. The furrows between the costae are equal or slightly greater in width than the costae. The costae are essentially uninterrupted and simple on the lateral and anterior slopes of the valve, increase by bifurcation being apparently restricted to the extreme posterior portion of the shell. On the postero-lateral slopes and extending across the cardinal auriculations rather strong concentric wrinkles cross the radiating costae, producing an ill-defined semireticulate pattern.

Brachial valve with moderate concavity, somewhat flattened in the visceral portion, curving very abruptly to the lateral and anterior margins. Corresponding to the shallow mesial sinus of the pedicle valve is a well defined mesial fold beginning about the mid-length of the valve and continuing with better definition to the anterior region. The cardinal auriculations crossed by strong concentric ribs are not so sharply differentiated from the remainder of the valve. The surface is marked by narrow radiating costae similar in size and number to those of the pedicle valve and ornamented by the rather numerous irregularly placed spine base nodes. As observed in the case of the pedicle valve, the bifurcation of the costae is largely restricted to the posterior part of the shell. Cardinal process prominent, bifid.

Remarks—This species is evidently a rather thin-shelled form since of a considerable number of specimens collected, all are more or less distorted or crushed. Most closely related to it are *P. viminalis* White of the Burlington, and *P. setigerus* Hall of the Keokuk. From the former, which it resembles particularly in size and general form, it may be distinguished by its greater proportional width, narrower umbonal region and its finer

costae. From *P. setigerus* to which, perhaps, this species most nearly approaches, it may be distinguished by its greater average size, its well defined mesial sinus and fold, and the character of its costae. Though comparable in number per centimeter with *P. setigerus*, the costae of *P. newtonensis* may be distinguished readily from those of both the allied forms by their more angular form, the rather scattered spine-bases which they bear, and the presence of inter-furrows broader than the costae.

Horizon—Reeds Spring limestone member of the Boone formation.

Locality—One-fourth mile below Grand Falls, Shoal Creek, six miles south of Joplin, Newton County, Missouri; Walker Museum 32120, Moore Collection.

Genus *Pustula* Thomas

Pustula echinata Moore n. sp.

Plate XI, Figs. 22-27

Description—Shell small, a little wider than long, the greatest width about the mid-length of the shell, the cardinal extremities obtusely angular. The measurements of two nearly perfect specimens, the cotypes, are as follows: length from hinge-line to front margin 9.4 mm. and 12 mm., length from umbonal region to front margin 10.2 mm. and 13.4 mm., length of hinge-line 19.2 mm. and 12 mm., greatest width 10.3 mm. and 14.2 mm., convexity 5.2 mm. and 5.4 mm.

Pedicle valve strongly convex, the greatest convexity posterior to the middle, the umbonal region compressed laterally, prominent and somewhat protuberant posteriorly beyond the hinge-line. The surface curves abruptly to the cardinal extremities which are flattened into well-defined auriculations, and to the lateral margins. The slope to the anterior margin is more gentle, and with uniform lateral convexity, the mesial sinus being obsolete. The beak is small and incurved. The surface is marked by abundant, irregularly placed fine, elongate nodes which mark the position of spines which were directed anteriorly at a relatively low angle from the surface of the valve. These spine nodes are smaller and shorter in the umbonal region and very closely spaced, on the produced portion of the valve larger and very much more elongate. On the area of the cardinal auriculations the spines are directed nearly vertically outwards from the shell, the spine bases being placed in the close concentric wrinkles which traverse the auriculations. The lateral and umbonal regions of the valve are marked by appressed, concentric folds of the shell, forming fine ribs, but these become obsolete in the mesial region and on the anterior portion of the shell.

The brachial valve is moderately concave but shallow, the greatest depth occurring near the beak. Mesial fold obsolete. Surface marked by numerous small spine nodes similar to those of the pedicle valve but about the same in size throughout. Concentric growth lamellae are more pronounced than on the pedicle valve.

Remarks—*P. echinata* most closely resembles *P. morbilliana* (Win.) of the Lower Burlington, with which it is closely similar in size and general outline. It is distinguished from that form by the difference in ornamentation and details of shape. Instead of the very clear concentric bands of spine bases observed on *P. morbilliana*, the ornamentation of this species is characterized by a general distribution of the spine-bearing nodes, resembling in this respect some of the closely spined *Productellas*. The relative length of the hinge-line is greater in *P. echinata*, and the greatest width is not found in the anterior portion of the shell. From *Pustula millespinosa* (Girty), which occurs in the lower part of the Boone limestone at St. Joe, Arkansas, this species is distinguished by its lesser convexity, more prominent, narrowed and protuberant umbonal region, and the irregular arrangement of the more elongate spine-bearing nodes. In *P. millespinosa* the small rounded spine bases are arranged in well-defined concentric rows, suggesting the semireticulate pattern of some species of *Productus* rather than ordinary *Pustula* or *Productella*.

Horizon—Chouteau limestone.

Localities—Bed 1, small gully 200 yards above Snake Den on Little Fabius river, 2 miles southwest of Newark, Knox County, Missouri; Walker Museum, Moore collection, cotype. The other cotype is from the Chouteau limestone, Chouteau Springs, Cooper County; Walker Museum 9825, Sampson Collection.

Pustula laevicula Moore n. sp.

Plate XI, Figs. 13, 14

Description—Shell very small, longer than wide, the hinge-line shorter than the greatest width which is located near the mid-length of the shell. The dimensions of a nearly complete pedicle valve, the holotype, are as follows: length from hinge-line to front margin 7 mm., length from umbonal region to front margin 7.5 mm., greatest width 6.2 mm., length of hinge-line 5.2 mm., convexity 4 mm.

Pedicle valve very strongly convex, the greatest convexity posterior to the middle of the shell, the umbonal region narrowed laterally, prominent and protuberant beyond the hinge-line. The surface, which is rather narrowly rounded transversely throughout the length of the valve, slopes very abruptly from the umbonal region to the cardinal extremities and to the lateral margins, slightly more gently to the anterior and anterolateral margins. The cardinal auriculations are compressed and well defined, but very small and inconspicuous. Mesial sinus obsolete; beak strongly incurved, extending beyond the hinge-line. Except for scattered spine bases the surface is almost absolutely smooth. There is no trace of radiating costae, concentric wrinkles are absent, and even the fine growth striae, which may be observed on similar forms, are essentially lacking. The spine bases, though plainly distinguished, are not elevated above the surface of the valve in elongate nodes, but are slightly raised rounded pustules, the spines having been directed nearly at right angles to the shell surface.

Brachial valve not observed.

Remarks—This *Pustula indianensis*-like form suggests both the Spergen species and a new species here described from the Chouteau limestone, *Pustula newarkensis*. It is broader and fuller than *P. indianensis* in the middle and anterior portions of the shell and the umbonal region is distinctly less strongly protuberant. From *P. newarkensis* it differs in its narrower relative width, more gently sloping sides, and less truncate anterior margin. In its ornamentation it is readily distinguished from both of these species.

Horizon—Sedalia (?) limestone, Lower Burlington limestone.

Locality—Lower Burlington limestone, Hannibal, Marion County, Missouri; Walker Museum 32109, Moore Collection. Sedalia (?) limestone, Warsaw, Benton County, Missouri.

Pustula arctifossa Moore n. sp.

Plate X, Figs. 7-11

Description—Shell of medium size, distinctly wider than long, the hinge-line a little shorter than the greatest width of the shell, the cardinal extremities obtusely angular or rounded. The dimensions of the holotype are as follows: length from hinge-line to front margin 29 mm., length from the umbonal region to the front margin 32 mm., greatest width 41 mm., length of hinge-line 32 mm., convexity of the pedicle valve 13 mm., depth of visceral cavity between the two valves 9.4 mm. The measurements of a nearly perfect mold of a brachial valve are: length from hinge-line to front margin 20 mm., width of hinge-line 24 mm., greatest width of valve 27.5 mm.

The pedicle valve is moderately convex with the point of greatest convexity posterior to the middle, the surface curving abruptly from the umbonal region to the cardinal line and the inner side of the flattened cardinal extremities, more gently to the anterior

margin. The umbonal region is narrowly compressed laterally, prominent and quite distinct from the flattened auriculate expansions of the compressed postero-lateral regions. It is however, protuberant only a short distance beyond the hinge line and the beak is closely incurved over the brachial valve. A very shallow ill-defined sinus or broad mesial flattening is observable from the mid-portion of the valve to the anterior margin, but is not traceable to the umbo. The surface of the valve is marked by numerous, closely spaced, well-marked concentric ridges or ribs, abruptly elevated on the anterior side, slightly more gentle in slope posteriorly. On the crests of the ribs are regularly spaced, slightly anteriorly directed spines, 3 to 4 in the space of 1.0 mm. and in the furrows which separate the concentric wrinkles are small regular elevations which appear to be directly related to the spines. A well preserved portion of the shell, therefore, appears as a closely and uniformly wrinkled surface studded by innumerable delicate but very distinct spine bases.

Brachial valve concave at the beak, the concavity extending anteriorly with broadly diverging, but indefinitely marked lateral borders which intersect the lateral margins a little anterior to the mid-length of the valve. The broad triangular areas toward the cardinal extremities are flattened, the visceral portion not sharply differentiated from the produced part. Near the middle of the valve a low, broadly flattened, ill-defined mesial fold originates, widening anteriorly to include most of the front margin of the shell. Surface marked with closely spaced fine, concentric ribs bearing minute appressed spines similar to those of the pedicle valve.

Remarks—This shell is very distinct from any described species of *Pustula* known in the Mississippian. The very broad, flat shape of the shell, the reduced umbonal region and the closely spaced concentric ribs with their regularly spaced spines are all diagnostic of this species.

Horizon—Lower Burlington white chert, and Pierson limestone.

Locality—Lower Burlington, Quarry west of Osage river, Osceola, St. Clair County, Missouri; Walker Museum 32114, holotype, Moore Collection. Pierson limestone, near Springfield, Greene County, Walker Museum 9558, Weller Collection.

Pustula newarkensis Moore n. sp.

Plate XI, Figs. 8-10, 15, 18, 19

1915. *Productella concentrica* Girty, U. S. Geol. Survey, Bull. 598, p. 11, Plate I, Figs. 3, 3a, 3b.

Description—Shell very small, width nearly equal to length, the hinge-line a little shorter than the greatest width which is found toward the anterior end of the shell. The dimensions of two nearly perfect pedicle valves, cotypes, are: length from hinge-line to front margin 6.8 mm. and 6 mm., length from umbonal region to front margin 8 mm. and 6.7 mm. greatest width 7 mm. and 5.9 mm., length of hinge-line 6.7 mm. and 5.6 mm., convexity 5 mm. and 4 mm.

Pedicle valve strongly convex, the greatest convexity slightly posterior to the middle though the curvature from the umbo to the front margin of the shell is nearly the same throughout; the umbonal region broad and prominent, protuberant well beyond the hinge-line, narrowly rounded transversely, the surface sloping very abruptly to the lateral margins, more gently to the anterior margin, compressed toward the cardinal extremities; the aurications well defined though not conspicuous; mesial sinus obsolete; beak strongly incurved, extending beyond the hinge-line. Surface without regular radiating costae or well-defined concentrically banded spine bases, but marked by fine, closely spaced, slightly wavy concentric lines of growth, the wavy irregularity and the prominence of the lines increasing toward the anterior margin of the shell. Spine bases of moderate size, which, especially in the anterior portion of the shell, are accompanied by a slight elevation of the surface into faintly marked discontinuous

costae, are scattered over the shell, extending well over the umbonal region. In some examples, the spine bases are arranged in ill-defined concentric bands.

The brachial valve rather deeply concave, the average depth about one-half the convexity of the pedicle valve, surface much compressed toward the cardinal extremities to form small but very well defined aurications, the umbonal region very shallow concave, the greatest concavity of the valve toward the anterior margin but without a sharp geniculate turn; surface marked by somewhat irregular concentric growth lines and toward the anterior margin by very ill-defined low costae. Mesial fold obsolete.

Remarks—In size, shape, and general surface markings, *P. newarkensis* is strongly suggestive of *Pustula indianensis* (Hall) which occurs characteristically in the Spergen limestone of Indiana and Illinois. *P. newarkensis* is relatively wider and shorter in outline and the antero-posterior curvature of its pedicle valve is much more uniform than *P. indianensis*, the greatest convexity of whose shell is distinctly posterior to the middle. A further differentiating feature is found in the relative length of the hinge-line which, distinctly less than the greatest width of the shell in *P. indianensis*, is nearly or quite equal to it in *P. newarkensis*. In some respects *P. newarkensis* resembles *Pustula concentrica* but it is distinct from that species. Though fully mature, judging from the convexity of the pedicle valve, and the considerable number of specimens of uniform size and development found, this shell is less than one-third or one-half the size of *P. concentrica* which also is proportionally broader and with greater posterior convexity. Girty has referred to *P. concentrica* a minute shell from the Boone limestone of St. Joe, Arkansas, which appears referable to this species, though it may represent a type transitional between it and *P. indianensis*.

Horizon—Chouteau limestone.

Localities—Beds 2 and 3 Chouteau limestone, Snake Den on Little Fabius river, 2 miles southwest of Newark, Knox County, Missouri; Walker Museum 32153, cotypes, Moore Collection. Bed 8, Chouteau limestone, Missouri, Kansas and Texas Railroad quarry, Sweeney, Cooper County; Reeds Spring limestone near Grand Falls on Shoal Creek, Newton County.

Genus *Avonia* Thomas

Avonia pustulifera Moore n. sp.

Plate XI, Figs. 7, 11, 12, 16, 17, 20, 21

Description—Shell small, very plump, length approximately equal to width, the hinge-line equalling or but slightly less than the greatest width of the body of the shell, the lateral margin curving evenly forward from the cardinal extremities without flexure. The dimensions of two nearly complete pedicle valves, the cotypes are: length from hinge-line to the anterior margin 7.7 mm. and 8.9 mm.; length from the umbonal region to the anterior margin 8.7 mm. and 10.5 mm.; length of hinge-line 7.6 mm. and 8.5 mm. (?); maximum width of shell 8 mm. and 9.8 mm.; convexity of pedicle valve 6.6 mm. and 7 mm.

Pedicle valve ventricose, umbonal region somewhat compressed, projecting but a short distance beyond the hinge-line, the beak not incurved over the dorsal valve, the surface curving very abruptly to the cardinal margins and lateral slopes, more gently to the anterior margins, narrowly compressed toward the cardinal extremities forming small but well defined aurications; mesial sinus obsolete, the contour of the shell remaining perfectly rounded throughout. Surface of the valve marked by slightly elevated pustules carrying the conspicuous bases of the spines which are somewhat uniformly though not thickly distributed from the umbonal region to the lateral and anterior portion of the shell; the posterior one-half of the valve bearing numerous concentric wrinkles which toward the mid-portion of the shell become broad and ill-defined, being replaced in the front part of the shell by fairly well marked longitudinal costae.

The costae are initiated by the elongate node-like elevations of the spines and are continued by the coalescence with them of other properly aligned elongate pustules. Minute slightly wavy concentric lines of growth cross the costae and intervening furrows. Internal characters not observed.

Brachial valve not known.

Remarks—This species may be distinguished very readily from other *Avonias* by its small size, strong convexity and low very full umbonal region. The strongly marked spine bases and pustuled anterior costae are also characteristic. This is the only small representative of the genus *Avonia* recognized at present in the Lower Mississippian. All the specimens known are beautifully preserved in white chert of the Lower Burlington and Sedalia limestone.

Horizon—Lower Burlington, Sedalia.

Localities—Lower Burlington limestone in quarry west of Osage river, Osceola, St. Clair County, Missouri; Walker Museum 32113, Moore Collection. Sedalia limestone, Pettis County, Walker Museum 9849, Sampson Collection.

Genus *Cranaena* Hall and Clarke

Cranaena occidentalis (Miller)

Plate XII, Figs. 1-6

1892. *Terebratula occidentalis*. Miller, Adv. Sheets, 18th Rep. Geol. Surv. Ind. p. 59, pl. 9, figs. 10-13.

1894. *Terebratula occidentalis*, Miller, 18th Rep. Geol. Surv. Ind., p. 313, pl. 9, figs. 10-13.

1914. *Cranaena* sp., Weller, Ill. Geol. Surv., Mon. 1, pl. 34, figs. 52-54.

Description—Shell small, subovate in outline, broadest near the mid-length of the shell, pedicle valve most convex. The dimensions of two complete examples are: length of pedicle valve 11.7 mm. and 9. mm., length of brachial valve 9.8 mm. and 7.6 mm., greatest width 8.8 mm., and 6.9 mm., thickness 6.5 mm. and 5 mm.

The pedicle valve is strongly convex, the greatest convexity posterior to the middle, the curvature along the median line becoming regularly more convex posteriorly. The surface curves abruptly from the umbonal region to the postero-lateral margins becoming inflected near the beak. Toward the anterolateral margins the slope is more gentle, the front part of the valve in many examples exhibiting a slight flattening suggestive of a shallow, almost obsolete sinus. The beak is prominent, incurved and pierced by a subcircular foramen which in some specimens appears entirely distinct from the delthyrium, in others barely touching it at its apical portion. The delthyrium is large, but covered in large part by the incroachment of the beak of the opposite valve. Deltidial plates enclose the remaining portion of the delthyrium.

The brachial valve appears a little less convex than the pedicle, the greatest convexity slightly posterior to the middle, the curvature of the surface along the median line from beak to front regular. The slope from the umbonal region is most abrupt to the posterior and postero-lateral portions of the valve, most gradual to the anterolateral and front margins. Toward the front it is noticeably flattened on some specimens. Beak acutely pointed, incurved beneath the base of the pseudo-detidium of the opposite valve. Examination of the rostral portion of the valve has shown the absence of median septum or diverging crural lamellae, differentiating this species, therefore, from *Girtyella* and *Dielasma*.

The surface of both valves is marked by concentric lines of growth which toward the anterior portion become very thick and prominent in some specimens. The shell structure is observed to be finely and closely punctate.

Remarks—This species was very inadequately described and figured by Miller from material furnished by R. A. Blair from the Chouteau limestone near Sedalia, Missouri.

Owing to the doubtful features connected with Miller's description and the absence of type material at the time Dr. Weller published his Monograph on the Mississippian brachiopoda, this species was not included. There seems to be little doubt that well preserved specimens of *Cranaena* collected by the writer from the Chouteau limestone in Missouri belong to the same form which Miller figured, so that the species is described in this report. Figures 52-54, Plate XXXIV of Dr. Weller's Monograph, belong to this species.

Horizon—Chouteau limestone.

Localities—Pettis County, Missouri; Walker Museum 9716, Sampson Collection. Chouteau limestone, Beds 2 and 3, Snake Den, on Little Fabius river, 2 miles southwest of Newark, Knox County, Missouri, Walker Museum 32112, Moore Collection.

Cranaena hannibalensis Moore n. sp.

Plate XII, Figs. 9, 10

Description—Shell of medium size, larger than common in *Cranaena*, subovate in outline, longer than wide, the greatest width near the mid-length of the shell, the valves subequally convex. The dimensions of a complete pedicle valve and a nearly complete internal cast of both valves are as follows: length of pedicle valve 17 mm. and 18.5 mm., length of brachial valve 16.3 mm., greatest width 15 mm. and 15.8 mm., thickness (pedicle valve) 5 mm. (both valves) 10.7 mm.

The pedicle valve is strongly convex, the greatest convexity posterior to the middle, arched from the beak to the front margin with regularly increased curvature posteriorly. The surface curves abruptly from the median line to the postero-lateral margins, becoming inflected toward the margins. Toward the antero-lateral and front margins the slope is more gentle. The mesial portion of the valve is not differentiated, all trace of a sinus being absent. The beak is prominent, incurved and pierced by a rather large, subcircular foramen which encroaches on the umbonal region of the valve, entirely distinct from the delthyrium, or touching it only at its apex. In the internal cast the dental plates of the pedicle valve are well defined in the neighborhood of the beak but cannot be traced far forward. More or less indefinite markings radiating from the beak are probably obscure muscle scars.

The brachial valve is a little less convex than the pedicle, the greatest convexity near the middle, the surface nearly uniformly arched from beak to front margin. From the mesial line the curvature is slightly more abrupt to the postero-lateral margins, gentler to the antero-lateral. The mesial portion of the valve slightly flattened in some specimens, but otherwise not differentiated from the surface of the valve; mesial fold obsolete. Except for the absence of crural lamellae or a median septum which distinguish this species respectively from *Dielasma* and *Girtyella*, the internal features of the brachial valve are not observed.

The surface of the shell is in general quite smooth. Growth lines may be distinguished at various places, increasing in number and distinctness toward the anterior margin. The type specimens do not show the punctate structure which characterizes all terebratuloids, but there can be little doubt that its absence is to be explained on the condition of preservation of the fossils. The finer details of structure are rarely preserved in fine, porous sandstone similar to the Hannibal. Punctate structure is observed on examples probably belonging to this species from the base of the Burlington overlying the Hannibal in this region.

Horizon—Hannibal formation, Northview sandstone.

Location—Louisiana, Pike County, Missouri; Walker Museum 32105 cotypes, Weller Collection. Northview formation, Webster County, Missouri; Walker Museum 5956, Weller Collection.

Genus *Spirifer* Sowerby*Spirifer buehleri* Moore n. sp.

Plate XII, Figs. 17, 18, 19, 43

Description—Shell above medium size, much wider than long, the greatest width along the hinge-line. The dimensions of two nearly complete pedicle valves, the types, are: length 30 mm., and 28 mm., width along hinge-line 77 mm. and 74 mm., height of cardinal area 5.6 mm. and 5.5 mm., depth 14 mm. and 13 mm.

The greatest convexity of the pedicle valve is distinctly posterior to the middle though the curvature is in no part strong. The umbonal region is prominent with the slope to the cardinal margin on either side of the beak abrupt, but toward the cardinal extremities the valve is almost flat. The slope from the umbonal region to the lateral extremities of the valve varies from a nearly straight line to one which is distinctly concave. The lateral extremities are broad and compressed somewhat in the plane of the valve. The mesial sinus is rather narrow, of moderate depth, rounded at the bottom and distinctly defined to the beak. The beak is small, narrowly appressed and sharply incurved over the cardinal area which is of moderate height, curved, with the curvature increasing toward the beak. The lateral margins are very sharply defined and toward the extremities become subparallel to the hinge-line. The lower flatter portion of the area lies at an angle of about 80° to the plane of the valve. The delthyrium is large, the width about equal to the height. Each lateral slope is marked by 30 to 35 rather angular, radiating plications separated by narrow angular furrows. The plications are in part simple, especially toward the lateral extremities where they are uniformly finer than in the central portion of the shell. In general, however, the plications are bifurcated, but no more than one bifurcation is observed for each initial plication. The mesial sinus is marked by a median simple plication which may be traced quite to the beak, and by lateral plications, 4 to 6 in number, which originate by bifurcation from the inner side of the plications which bound the sinus.

The surface of the valve is, in addition, marked by fine, crowded, regularly spaced, concentric lamellose lines, which may be more closely crowded at intervals. Slight thickenings of the shell form concentric lines of growth. These growth lines indicate that in the youthful stages of the shell the hinge-line was already much extended.

Remarks—*Spirifer buehleri* is very readily distinguished from any previously described species from the Mississippian. In its peculiarly extended, alate form, it is most suggestive of *S. forbesi* but there is little in common even with this species. In *S. forbesi* the hinge-line is more widely extended and the lateral margins more sharply constricted to form an acute angle at the cardinal extremities, the mesial sinus is shallower and the angle of the plane of the cardinal area to that of the valve is much greater than in *S. buehleri*. Very important, however, is the bifurcating habit of the plications of *S. buehleri* which, being entirely foreign to other shells resembling it in form, may be regarded as highest in diagnostic value.

Horizon—Reeds Spring limestone member of the Boone formation.

Locality—One-fourth mile below Grand Falls, Shoal Creek, Newton County, Missouri; Walker Museum 32121, cotypes. Moore Collection.

Spirifer piersonensis Moore n. sp.

Plate XII, Figs. 20-22

Description—Shell small, subtriangular in outline, wider than long, the greatest width along the hinge-line which is extended into well-defined alations. The dimensions of the holotype are: length of pedicle valve 10.8 mm., length of brachial valve 8.2 mm., width along hinge-line 16.5 mm., thickness 7.8 mm., height of cardinal area 2.5 mm., width of mesial sinus in front 3.5 mm.

The pedicle valve is strongly convex, the greatest convexity posterior to the middle and well back on the umbonal region, which is narrow and prominent with the surface curving steeply away to the cardinal and antero-lateral margins. The beak, not well preserved in the type specimen, is small, and incurved. The cardinal area is distinctly curved beneath the beak, broad, but almost flat and nearly uniform in height toward its extremities. The lateral margins of the area which are very sharply defined, slope abruptly from the beak but toward the extremities are rapidly flattened and nearly horizontal, subparallel to the hinge-line. The lateral slopes of the valve are convex antero-posteriorly with sharp curvature toward the cardinal margin, the slope from the umbonal region to the cardinal extremities being nearly straight. Each lateral slope is marked by 7 to 8 simple, broadly flattened, radiating plications which toward the cardinal margin and lateral extremities of the shell are less well defined. The mesial sinus is narrow, of moderate depth, rounded on the bottom and without plications.

The brachial valve is less convex than the pedicle, but with distinct, rather equally distributed antero-posterior curvature. The mesial fold is well defined throughout, moderately elevated above the general level of the shell, and smooth except for a very slight median depression which is traceable to the beak. The lateral slopes are full, rounded, without important flattening toward the cardinal extremities. They are marked by low, broad rounded plications similar in number and arrangement to those of the pedicle valve.

The surface of the shell is marked by very fine, regularly spaced, concentric striae and by occasional coarser concentric lines of growth.

Remarks—This species is most closely related to *Spirifer louisianensis* Rowley, with which it agrees in size and general outline. It is distinguished from that species by the broad low, rounded form and much smaller number of its plications, its non-plicated fold and sinus, the nearly uniform height and sharply defined character of its cardinal area and the more uniform convexity of both valves.

Horizon—Pierson limestone.

Locality—Dry Fork Sac river 9 miles northeast of Springfield, Greene County, Missouri; Walker Museum 32116, Moore Collection.

Spirifer vantuyli Moore n. sp.

Pl. XII, Figs. 11-16

Description—Shell moderately small, subelliptical in outline, with hinge-line shorter than the greatest width of the shell, cardinal extremities rounded or nearly rectangular. The measurements of two pedicle valves, cotypes, are: length 15.6 mm. and 18 mm., greatest width 18.1 mm. and 20 mm., width of hinge-line 17.4 mm. and 18 mm., height of cardinal area — and 5.7 mm., of two brachial valves length 13.8 mm. and 16.1 mm., greatest width 17.2 mm. and 21 mm.

Pedicle valve moderately convex with the greatest convexity posterior to the middle and well toward the umbonal region of the shell. Surface slopes abruptly to the cardinal margin but more gently and with fairly uniform curvature to the lateral and anterior margins. Beak small, pointed and incurved moderately over the cardinal area which is relatively high, concave and possessing sharply defined lateral margins. Toward the cardinal extremities the margin becomes nearly parallel with the hinge-line and the area is abruptly terminated before the upper margin reaches the hinge-line. The delthyrium is narrowly triangular, the width being approximately two-thirds of the height. A well defined mesial sinus originates at the beak and becomes gradually broader toward the anterior margin of the valve. Each lateral slope is marked by 9 to 12 broad, depressed simple plications which are separated by narrow grooves. The mesial sinus marked by a low median plication traceable nearly to the beak and on each side and ill-defined plication which originates on the inner side of the plication bounding the sinus.

The brachial valve is less convex than the pedicle, the greatest depth slightly posterior to the middle, slightly compressed toward the cardinal extremities. Beak small, well defined, sharply incurved. A rather broad, ill-defined mesial fold, scarcely elevated above the general surface of the valve is bounded by slightly stronger furrows. It is marked by four low plications two of which extend to the beak, the outer two originating by bifurcation of the inner. Each lateral slope is marked by plications similar in character and number to those of the pedicle valve.

Remarks—This species is characterized by its subcircular outline, rotund form and coarse, depressed simple plications. In general form it is probably most suggestive of *S. latior* but it is readily distinguished from this rather rare species by its uniformly greater size, and the coarseness of its plications. Some specimens of *S. louisianensis* are somewhat suggestive of it but *S. vantuyli* is not extended along the hinge-line, has much coarser and fewer plications and is greater in size. From both of the species mentioned *S. vantuyli* is distinguished by the character of its cardinal area which does not come to a point at the cardinal extremities.

Horizon—Chouteau limestone.

Locality—Kiesinger Bluff, 2 miles north of Warsaw, Benton County, Missouri—Walker Museum 32115, Moore Collection.

Genus *Syringothyris* Winchell

Syringothyris pikensis Moore n. sp.

1914. *Syringothyris* ? sp. Weller, Ill. Geol. Survey, Mon. 1, pl. LXXI, figs. 8, 9.

Description—Shell medium size, much broader than long, the greatest width along the hinge-line, the cardinal extremities acutely angular. The dimensions of two nearly perfect examples cotypes, are as follows: length of pedicle valve beak to front margin 16 mm. and 24 mm., length of brachial valve 17 mm., and 20 mm., height of cardinal area 15 mm. and 19.4 mm., width along hinge-line 38 mm. and 50 mm., width of delthyrium at base 7.4 mm., and 8.5 mm., thickness 17.4 mm., and 39.2 mm., width of sinus in front 9 mm. and 15 mm.

Pedicle valve subpyramidal in form, the surface sloping from the beak to the cardinal extremities and to the anterior extremities in nearly straight lines. The mesial sinus is of moderate depth, rounded at the bottom and sharply defined to the beak. It increases uniformly in width with rather well marked limits, and is produced as a very slight rounded expansion fold of the brachial valve. The cardinal area is high and broadly triangular in outline sloping posteriorly from the hinge-line at an angle of 60-65 degrees to the plane of the valve. The vertically striated differentiated portion of the cardinal area is bounded by lines diverging from the beak at an angle greater than the divergence of the sides of the delthyrium, the base of the triangular area inclosed more than equaling the width of the delthyrium (12.5-5). The delthyrium is narrowly triangular, the height greater than twice the width. The lateral slopes of the valve bear about 14 to 16 simple, depressed plications, which, originating along the cardinal margins, grow successively finer toward the cardinal extremities. Internal characters not observed.

Brachial valve much shallower than the pedicle, in some specimens nearly flat. The greatest depth is on the median line near the front margin of the valve, the surface curving more abruptly to the cardinal margin, somewhat compressed toward the cardinal extremities. The mesial fold is distinctly defined to the beak but is much flattened and only slightly elevated above the general surface of the shell. The beak is small and projects but a short distance beyond the hinge-line. Each lateral slope is marked by simple, broad, flat plications similar in number and position to those of the pedicle valve, but rather stronger.

The minute surface markings including the punctations of the shell, are not defined on the specimens, owing to the character of their preservation in the sandstone. More or less strong concentric lines of growth are observed on both valves.

Remarks—This species of *Syringothyris* from the Hannibal sandstone, is very suggestive of *S. halli* Winchell which is described from the Kinderhook of Burlington, Iowa. *S. halli* has been confused by some authors with *S. extenuata* but Weller has sufficiently differentiated these quite distinct forms, the former occurring in Bed 4 at Burlington, the latter restricted to lower horizons, Beds 2 and 3. From *S. halli* the species here described differs essentially in its uniformly larger size, relatively higher and slightly more erect cardinal area, relatively narrower delthyrium and the much flatter fold of the brachial valve. Notwithstanding these distinguishing features, however, the Hannibal species is very suggestive of *S. halli*, and it is possible that in its general outline, the angle of the cardinal area to the plane of the valve, and in other features there is a genetic relation between them. Except in the general shape of the cardinal area, *S. pikensis* has little or nothing in common with *S. extenuata* which is characterized by the greatly compressed lateral slopes of its pedicle valve, the wide, deep mesial sinus with its corresponding fold and the low angle of inclination of the cardinal area. The type specimen is illustrated by Weller in his Monograph on Mississippian brachiopoda (Figured Plate LXXI, Figs. 8, 9).

Horizon—Hannibal sandstone and shale.

Locality—Louisiana, Pike County, Missouri, (Walker Museum No. 13964, Weller Collection).

Genus *Eumetria* Hall

Eumetria swallowi Moore n. sp.

Plate XII, Figs. 7, 8

Description—Shell rather less than medium size, elongate subovate in outline, the greatest width near the mid-length of the shell. The species is described from a nearly perfect, beautifully preserved brachial valve, the dimensions of which are as follows: length 19.2 mm., width 13 mm., convexity 6 mm.

The brachial valve is most convex posterior to the middle, the curvature along the median line of the valve increasing regularly from the front margin, changing from almost flat in the anterior portion to rather strongly convex in the posterior portion. The beak is rather large, cuspidate, slightly incurved, the umbonal region subcuneate in form. The slope from the umbonal region to the postero-lateral margins is abrupt but not inflected; the antero-lateral slopes are flattened.

The surface of the valve is marked by simple, depressed, broadly flattened plications, the furrows between the plications much narrower than the plications. Toward the anterior margin about 2 plications occur in a space of 1 mm., about the mid-length of the valve 3 plications are included in 1 mm. The plications become finer and finer toward the umbonal region, converging toward the beak. They may be traced as minute striae almost if not quite to the tip of the beak. The shell structure, as is beautifully shown in the type specimen, is very finely and closely punctate. The punctae are arranged in a reticulating pattern of diagonal intersecting rows.

Remarks—This is a rare shell in the Chouteau limestone. Swallow described a similar species, somewhat larger than that here described, which he called *Retzia* (?) *popeana*. The measurement of this form are, according to Swallow, length 1 inch, (25 mm.), breadth .71 inch (17.5 mm.), thickness .42 inch (10.5 mm.). The specimen is not figured and the description does not adequately distinguish his species from other *Eumetrias*. However, the arrangement of the punctae in concentric rows is noted, and the practical absence of longitudinal costae is observed. These features would separate *E. popeana* from the species here considered, and since there is no indication as to the

geologic horizon or the locality from which the type of *E. popeana* was taken *E. swallowi* may be considered as a distinct form.

From other species of *Eumetria* occurring in the lower Mississippian *E. swallowi* may be distinguished with readiness by its narrow, elongate form, the distinct flattening of the anterior and lateral slopes, and the features mentioned regarding its ornamentation. The plications, which are evident in the specimen, are so delicate and slightly raised above the general surface that in the figures they are not distinguishable in the posterior portion of the shell.

Horizon—Chouteau limestone.

Locality—Branch on south side of Little Fabius river, one-fourth mile above Snake Den, on Little Fabius river, 2 miles southwest of Newark, Knox County, Missouri. Bed 3, Walker Museum 32154, Moore Collection.

Genus *Reticularia* McCoy

Reticularia cooperensis (Swallow)

An excellent specimen of a pedicle valve belonging to this species weathered completely so as to show the infernal characteristics with clearness is included in the Sampson collection from the vicinity of Sedalia. In this specimen the dental lamellae are very strongly developed and prominent. The median septum, however, which is generally strongly developed in the genus *Reticularia* is here almost obsolete, being represented merely by a faint median ridge. Sedalia limestone.

Genus *Martinia* McCoy

Martinia ? sp.

Plate XIII, Fig. 10

Description—In the collection from the fine-grained sandstone at the base of the Hannibal formation in Pike County, Illinois, in the vicinity of Pleasant Hill and Rockport, are a number of somewhat rotund, smooth shells which in general outline appear to belong in the genus *Martinia*. The cardinal area is poorly defined, the cardinal extremities are rounded and the shell bears a well defined median fold and sinus. The internal features, however, are unlike *Martinia* in the presence of well defined dental plates in the pedicle valve. *Martinia* is lacking both in median septa and dental plates. The Pike county specimens likewise differ from *Martiniopsis*, another smooth-shelled genus closely resembling *Martinia* in form, in the absence of the brachial septa which that genus contains. Neither *Reticularia* nor *Squamularia*, which resemble *Martinia* in outline but are distinguished by their surface ornamentation, have the same internal features observed in the specimens from Rockport and Pleasant Hill. It is possible, therefore, that the species in question belong to a new genus. It is thought best, however, to include it tentatively under the genus *Martinia* until additional evidence and better material is obtained.

PELECYPODA

Genus *Sphenotus* Hall

Sphenotus glaber Moore n. sp.

Plate XIII, Figs. 11-14

Description—Shell small, subrectangular in outline, rather strongly convex, with a prominent subumbonal ridge. The dimensions of right and left valves, cotypes, are as follows: 16 mm. and 15.1 mm., height 8.2 mm., convexity 3 mm. and 2.9 mm.

The hinge-line is slightly convex upward and shorter than the greatest width of the shell bending downward both posteriorly and anteriorly. The anterior margin short, very sharply rounded below the lunule which occupies more than one-half the height of the shell. The ventral margin is almost straight or slightly emarginate in the middle portion. The posterior margin broadly rounded below, obliquely truncate above, the upper portion meeting the hinge-line in an obtuse angle. The beak is prominent, but scarcely elevated above the hinge-line. It is flattened, incurved and is situated very near the anterior margin of the shell. From the beak to the postero-ventral margin there is a pronounced, regularly curved rather angular umbonal ridge with another less conspicuous ridge extending from the beak to the middle of the posterior margin. An ill defined, shallow but rather broad sinus extends from the beak obliquely to a point near the middle of the ventral margin. The greatest convexity of the valve is on the umbonal ridge not far from the beak.

The surface of the valve is almost smooth but close examination shows fine concentric lines of growth which are best defined in the outer portion of the shell.

Remarks—This species is distinguished by its small size, smooth surface subrect-angular outline and conspicuous umbonal ridge. It differs from *S. extensus* of the same fauna in its very much smaller size less extended form and different outline and in the smooth surface.

Horizon—Hannibal sandstone.

Locality—Louisiana, Pike County, Missouri; Walker Museum 32107, Weller Collection.

Sphenotus extensus Moore n. sp.

Plate XIII, Figs. 1-3

Description—Shell elongate, subelliptical in outline, rather strongly convex, the dimensions of two opposite valves, cotypes, being as follows: length 34 mm. and 36 mm., height 12.8 mm. and 13.7 mm., convexity 3.8 mm. and 4.9 mm. The hinge-line is gently arcuate, the dorsal margin sharply inflected inward to form a long cartilage groove. The anterior margin is very sharply rounded above to the anterior extremity of the hinge-line under the beak, becoming more regularly rounded below. The ventral margin is nearly straight or very gently curved throughout the greater part of its extent but is more sharply rounded anteriorly and posteriorly. The posterior margin is sharply rounded below and obliquely truncated above, meeting the hinge-line at an obtuse angle. The beaks are elevated above the hinge-line, narrowly compressed laterally, incurved and directed forward. The point of the beak is about one-sixth of the length of the shell from the anterior margin. A prominent rounded or rather angular umbonal ridge extends from the beak to the postero-ventral margin and the postero-dorsal slope is marked by an additional rather faint subangular ridge which is well defined to the beak. The greatest convexity of the valve is near the middle of the shell on or near the umbonal ridge. A shallow ill-defined sinus extends from the beak obliquely backward to a point anterior to the middle of the ventral margin. The surface is marked by well defined concentric lines of growth which are fine and closely spaced, and by less clearly marked fine radiating lines which converge toward the beak.

Remarks—*S. extensus* is chiefly distinguished by its compressed, elongate outline, narrow posterior portion and fine radiating markings. It is distinguished from *S. bicostatus* of the *Chonopectus* fauna by its general outline and less oblique posterior margin. From *S. cylindricus* of Bed 5 at Burlington which resembles this species in outline it differs in its much greater average size, narrower posterior portion and radiating markings. A number of excellent specimens of this species collected by Dr. Stuart Weller are in the collections of Walker Museum. The cotypes are from this material.

Horizon—Hannibal sandstone.

Locality—Louisiana, Pike County, Missouri; Walker Museum 32106, Weller Collection.

Genus *Grammysia* DeVerneuil

Grammysia welleri Moore n. sp.

Plate XIII, Figs. 4-6

Description—Shell very small, subelliptical in outline, the measurements of the holotype being: length 13.3 mm., height 7.6 mm., hinge-line 10 mm., convexity of left valve 2.2 mm.

The hinge-line is very slightly arcuate or almost straight. The anterior margin is short, abruptly rounded below the lunule which is rather deep, well defined and extended nearly one-half the distance to the base of the shell. The ventral margin is regularly and gradually curved from anterior to posterior extremities. The posterior margin is abruptly rounded in its lower portion, obliquely truncate above, being slightly indented midway between the hinge-line and the lower part of the valve at the depression in the postero-dorsal slope. The valves are regularly and gently convex in the posterior portion, becoming gibbous in the middle anterior and umbonal regions. The beaks situated near the anterior extremity of the shell are prominent, sharply elevated above the hinge-line, and incurved. A very marked rounded umbonal ridge extends in a shallow curve posteriorly from the beak to the lower posterior margin. The postero-dorsal slope contains a low secondary ridge nearer the hinge-line separated from the umbonal ridge by a narrow sinus.

Surface marked by strong, subangular or rounded concentric undulations which are very well defined anterior to the umbonal ridge, almost obsolete on the postero-dorsal slope.

Remarks—This species is most closely similar to *G. plena* of the English River (*Chonopectus*) sandstone at Burlington, Iowa. It differs from that species in its very much smaller size, absence of the broad shallow sinus slightly posterior to the beak and in the practically obsolete character of the concentric undulations on the postero-dorsal slope.

Horizon—Hannibal limestone.

Locality—Louisiana, Pike County, Missouri; Walker Museum 32102, Weller Collection.

Genus *Aviculopecten* McCoy

Aviculopecten welleri Moore n. sp.

Plate XIII, Figs. 18-21

Description—Shell small, subcircular, length of the hinge-line slightly less than the greatest width of the shell. The measurements of two species, cotypes, are as follows: height 11 mm. and 12.8 mm., greatest width 11 mm. and 12.5 mm., length of hinge-line 10 mm. and 9 mm., convexity 2 mm. and 2.1 mm.

The beak is central, projecting a slight distance above the hinge-line. The anterior ear is small, depressed from the body of the valve and almost flat. Its anterior margin forms an acute angle with the hinge-line and slopes obliquely backward forming a nearly right angled notch with the circular margin of the shell. The posterior ear of the valve is not so sharply separated from the body of the valve. Its posterior margin forms an acute angle with the hinge-line similar to that of the anterior ear but it slopes in a gentle curve to the posterior margin of the shell. The posterior ear is almost flat and sharply depressed from the general surface of the valve. The lateral and basal margins of the shell are regularly curved. The convexity of the shell, only left valves being represented in the collection, is moderate and greatest toward the beak.

The surface of the shell including the anterior and posterior ears is ornamented by minute radiating costae, about 4 occupying the space of 1 mm. Less well defined fine, irregularly spaced concentric lines of growth are observed crossing the radiating costae.

Remarks—This rather symmetrical, finely ornamented little shell is distinct from described forms from other formations in the Kinderhook, its closest relatives being found apparently in *A. tenuicostus* of the *Chonopectus* fauna and a species of *Aviculopecten* figured by Herrick* from the Waverly of central Ohio. From *A. tenuicostus* the species here described differs essentially in the shape of the anterior ear, in the well defined posterior ear and in the absence of strong radiating ribs. The shell figured by Herrick agrees closely in size and general outline with the Hannibal sandstone species and may be conspecific with it. The radiating costae are slightly finer, apparently, in *A. welleri*.

Horizon—Hannibal sandstone.

Locality—Louisiana, Pike County, Missouri; Walker Museum 32104, Weller Collection.

Aviculopecten planulatus Moore n. sp.

Plate XIII, Fig. 22

Description—Shell subcircular, the hinge-line shorter than the maximum width of the shell. The dimensions of the holotype are: width 55 mm., height 57 mm., length of hinge-line 40 mm. The right valve which is the only part of the shell known is nearly flat. The beak is subcentral and scarcely elevated above the hinge-line. The anterior ear of the right valve is small, slightly inflected outward and separated from the body of the valve by a sharply defined, fossular depression, which becomes broader and deeper away from the hinge-line. Its anterior margin is abruptly rounded and turns obliquely backward below to form a rather sharply acute angle with the margin of the shell. Posterior ear of the valve not sharply separated from the body of the shell its posterior margin joining the hinge-line at nearly right angles and continues with very slight change of curvature into the posterior margin of the valve. The margin of the shell is nearly circular. So far as indicated the surface of the shell is smooth except for very slightly marked concentric growth lines.

Remarks—In its size, general outline and lack of surface ornamentation this species is entirely distinct from any shell described in the lower Osage group. It most closely resembles *A. amplus* Worthen of the Warsaw which is distinguished by the same general form and large size. The Warsaw species has a slightly longer, more sharply depressed anterior wing, is distinctly larger and bears well marked radiating costae in addition to better defined concentric lines of growth.

Horizon—Sedalia ? limestone.

Locality—Lovers Leap, Hannibal, Marion County, Missouri; Walker Museum 32108, Moore Collection.

Genus *Streblopteria* McCoy

Streblopteria lirata Moore n. sp.

Plate XIII, Figs. 15, 16

Description—Shell small, subelliptical in outline height greater than width. The dimensions of right and left valves, cotypes, are as follows: height 12.6 mm. and 11 mm., greatest width 11 mm. and 9.5 mm., convexity, 2.5 mm. and 2.1 mm.

The hinge-line is apparently not more than one-half the maximum width of the shell, although the posterior ear is not well preserved in any of the specimens observed.

*C. L. Herrick, Ohio Geol. Survey, vol. 7, pl. 24, fig. 4.

The beak is central and directed slightly anteriorly. The anterior ear of the right valve is slightly convex, sharply depressed below the body of the shell and separated from it by a narrow, distinctly marked furrow. Its anterior margin is abruptly rounded toward the hinge-line and forms a very acute angle with the anterior margin of the shell. The posterior ear is very narrow, flat, and hardly separated from the body of the shell. The lateral and basal margins of the valve are gradually and uniformly rounded. The greatest convexity occurs along the median line of the valve near the beak.

The left valve is essentially similar to the right but in the specimens observed has a less extended and sharply defined anterior ear. Its convexity is approximately that of the opposite valve.

The surface of both valves of this species is smooth, except for faint narrow radiating furrows about 1 mm. apart. Very poorly defined concentric lines of growth are developed in some specimens. The markings are characteristically less well defined on the right than on the left valve.

Remarks—The species is chiefly characterized by its small anterior wing, smooth, slightly furrowed surface and small size. It is not closely related to other described species of the *Kinderhook*. Type specimens collected by Dr. Stuart Weller.

Horizon—Hannibal sandstone.

Locality—Louisiana, Pike County, Missouri; Walker Museum 32103. Weller Collection.

CEPHALOPODA

Genus *Cyrtoceras* Goldfuss

Cyrtoceras caniniforme Moore n. sp.

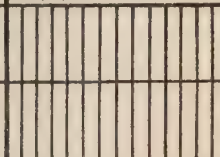
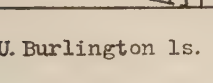
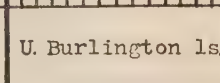
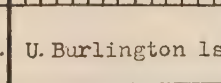
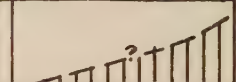
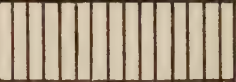
Plate XIII, Fig. 17

Description—Shell small, anterior portion almost straight, tapering to a very slight degree only, the posterior portion pointed and deflected, the ventral surface curving rapidly in this region. In shape this younger portion of the shell, which alone is preserved in the holotype, has a very close resemblance to a moderately sized canine. The greatest curvature on the concave side of the apical portion of the shell is 0.7 mm. in 15 mm. measured from the point. The greatest diameter of the shell 5 mm. The cross-section of the shell is very nearly circular anteriorly but apically it becomes a slightly elliptical with the rapid rounding of the venter, being compressed dorso-ventrally. The septa which may be discerned through the translucent outer shell are horizontal and numerous, the average distance between them in the anterior portion of the shell being 2.2 mm. Toward the apex they are more closely spaced. The siphuncle is obscure in the type specimen but appears to occur near the extreme ventral margin. The surface of the shell is perfectly smooth.

Remarks—Shells apparently intermediate between the typical forms of *Cyrtoceras* and *Orthoceras* similar to the species here described have been reported by de Konick* in the monographs upon the Carboniferous faunas of Belgium, and by Foord† in the Carboniferous of Ireland, but have not been recognized, so far as known in the Carboniferous faunas of North America. Dr. Stuart Weller has collected similar specimens from the Okaw limestone of the Chester which, while tapering slightly more than the species here described appear to belong to the same peculiar group. The species is distinguishable from members of the genus *Orthoceras* only by the features of the apical region. It is very possible, therefore, that the species has been previously referred to *Orthoceras*.

*L. G. de Konick, Faune du calcaire carbonifère de la Belgique, Annales du Musée Royal d'Histoire Naturelle de Belgique, Tome V, 2^{me} partie, Bruxelles, (1880).

†A. H. Foord, Monograph on the Carboniferous cephalopods of Ireland, Palaeont. Soc. Vol. 52, (1898).

Western Illinois		Northeastern Missouri		Southeastern Iowa	Southeastern Missouri
Jersey and Calhoun counties	Pike County	Pike and Ralls counties	Marion and Knox counties		
Pennsylvanian	Pennsylvanian	Pennsylvanian	Spergen ls. (Miss.)	Spergen ls. (Miss.)	Spergen ls. (Miss.)
			Warsaw fm.	Warsaw fm.	Warsaw fm.
			Keokuk ls.	Keokuk ls.	Keokuk ls.
U. Burlington ls.	U. Burlington ls.	U. Burlington ls.	U. Burlington ls.	U. Burlington ls.	
L. Burlington ls.	L. Burlington ls.	L. Burlington ls.	L. Burlington ls.	L. Burlington ls.	
Fern Glen ls. Sedalia ls.	Sedalia ls.	Sedalia ls.	Sedalia ls.	Wassonville ls. (Bed 7)	Fern Glen fm.
Chouteau ls.			Chouteau ls.	Chouteau ls. (Bed 6)	
Hannibal fm.	McKerney ls. sandstone shale	Hannibal fm.	Hannibal fm.	Prospect Hill ss. McKerney ls. English Riv ss. Maple Millsh.	Bushberg ss.
Glen Park ls.					Glen Park ls.
Louisiana ls.	Louisiana ls. (wells)	Louisiana ls.	Louisiana ls.		
Saverton and Grassy Ck. shale	Saverton and Grassy Ck. shale (wells)	Saverton and Grassy Ck. shale	Saverton and Grassy Ck. shale	Sweetland Ck. sh.	
Devonian to Silurian	Devonian to Ordovician	Devonian to Ordovician	Devonian to Ordovician	Devonian	Devonian to Ordovician

le formation names.

	GENERAL TIME SCALE	Northern Arkansas Northeastern Oklahoma	Southwestern Missouri		Central Missouri
			Jasper, Lawrence and Stone counties and southwest	Greene and Dade counties and north	
	Next younger time division represented	Moorefield sh (Miss.)	Cherokee sh. (Penn.)	Cherokee sh. (Penn.)	Cherokee sh. (Penn.)
OSAGIAN	Warsaw (Ill.)	Limestone and chert	Ls and cht (Warsaw)	Warsaw ls.	Warsaw ls.
	Keokuk (Ia.)		Short Ck oolite	Short Ck ool. mem.	
			Ls and cht (Keokuk)	Keokuk ls.	Keokuk ls.
	Burlington (Ia.)		Grand Falls' chert	U. Burlington ls.	U. Burlington ls.
			Reeds Spring ls	L. Burlington ls.	L. Burlington ls.
	Fern Glen (Mo.)	St Joe ls. member	St Joe ls.	Pierson ls.	Sedalia ls.
KINDERHOOKIAN	Chouteau (Mo.)			Chouteau ls.	Chouteau ls.
	Hannibal (Mo.)			Northview formation	
	Glen Park (Mo.)			Compton ls.	
	Louisiana (Mo.)				
	Chattanooga (Tenn.)	Chattanooga shale Sylamore ss.	Chattanooga shale Sylamore ss.	Chatt. sh. Sylamore ss.	Sylamore ss.
	Next older time division represented	Silurian to Ordovician	Ordovician	Ordovician	Devonian to Ordovician

FIG. 2.

Horizon—Chouteau limestone, Kinderhook.

Locality—One-fourth mile above Snake Den on Little Fabius river near Newark, Knox County, Missouri; Walker Museum 32111, Moore Collection.

Genus *Aganides* DeMontfort

Aganides compressus Moore n. sp.

Plate XIII, Figs. 7, 8

Description—Shell discoidal, involute, laterally compressed, the whorls high and impressed to about one-half their height by the inner volution. The height of the last whorl is nearly two-thirds the total diameter of the shell. The sides of the whorl are flattened, convex and smooth, curving gently to the narrower, rounded venter. The umbilical shoulders are abruptly rounded and the opening almost closed. The dimensions of a nearly complete specimen are as follows: diameter 37.5 mm., height of last whorl 23 mm., height of last whorl from the preceding 13 mm., width of last whorl 15.8 mm., involution 10 mm., width of umbilicus 2 mm.

The surface of the shell is ornamented by gently curving signoidal growth constrictions with a rather broad posteriorly directed sinus at the ventral margin.

The septa are of the usual *Aganides* type with a slightly spatulate, tongue shaped ventral lobe, deep and narrow and a sharply rounded lateral lobe. The external saddle is evenly rounded but directed slightly toward the venter, the lateral saddle is very broadly rounded.

Remarks—This species is distinctly compressed and discoidal in form, suggesting in its outlines *A. discoidalis* Smith of the Chouteau limestone. It is slightly greater in width but is chiefly distinguished by the character of the septal suture. In *A. discoidalis* the ventral lobe is not at all constricted anteriorly, there is not the corresponding ventral direction to the curvature of the external saddles and the lateral lobe is situated almost equidistant between the venter and umbilicus. The lateral lobe in *A. compressus* is rather sharply pointed and the lateral saddle very broadly rounded.

Horizon—Louisiana limestone.

Locality—Hamburg, Calhoun County, Illinois; Walker Museum 32117 (holotype), Moore Collection.

PLATE X

PLATE X

Productus calhounensis Moore n. sp.

- 1, 2, 3. Posterior, lateral and anterior views of a specimen from the "Chouteau limestone" near Springfield, Missouri. Weller Collection. W. M. 8571.
- 4, 5, 6. Posterior, lateral and anterior views of the holotype. Chouteau limestone, two miles south of Grafton, Calhoun County, Illinois. Moore Collection. W. M. 32118.

Pustula arctifossa Moore n. sp.

- 7, 8, 9. Pedicle valve, brachial valve and lateral view, respectively, of the holotype. White chert in the Lower Burlington limestone, Osceola, St. Clair County, Missouri. Moore Collection. W. M. 32114.
10. Portion of a brachial valve showing fine concentrically arranged spine bases. White chert in the Lower Burlington limestone, Osceola, Missouri. Moore Collection. W. M. 32114.
11. Mold of brachial valve of a typical specimen from the Pierson limestone near Springfield, Greene County, Missouri. Weller Collection. W. M. 9558.

Productus newtonensis Moore n. sp.

- 12, 13. Pedicle valve resting on brachial valve; holotype. Reeds Spring limestone about 10 feet below base of Grand Falls chert, one-fourth mile west of Grand Falls, on Shoal Creek, 6 miles south of Joplin, Missouri. Moore Collection. W. M. 32120.

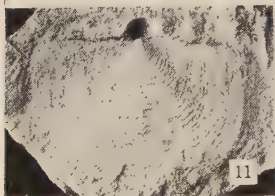
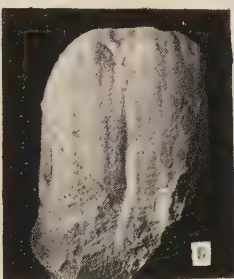
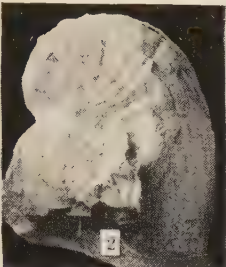
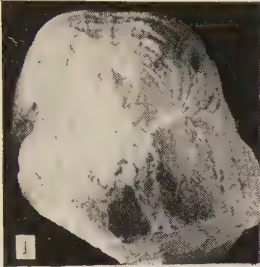


PLATE XI

PLATE XI

Orbiculoidea hardinensis Moore n. sp.

- 1, 2. Pedicle valve of a typical specimen; cotype. Shale at base of Hannibal formation, Cedar Creek, 2 miles north of Hardin, Calhoun County, Illinois. Moore Collection. W. M. 32122.
- 5, 6. Pedicle valve of an unusually large specimen; cotype. Same horizon and locality.

Chonetes alatus Moore n. sp.

3. Pedicle valve of an unusually large specimen; cotype. Hannibal formation, Kinderhook, Illinois, about 25 feet below base of McKerney limestone member. Moore Collection. W. M. 32123.
4. Pedicle valve of another specimen; cotype. Same horizon and locality.

Avonia pustulifera Moore n. sp.

- 7, 11, 12, 16. Posterior, anterior and side views of a cotype from the white chert in the Lower Burlington limestone, Osceola, St. Clair County, Missouri. Moore Collection. W. M. 32113.
- 17, 20, 21. Side and front views of a pedicle valve, cotype from the Chouteau limestone, Pettis County, Missouri; Walker Museum 9849, Sampson Collection.

Pustula newarkensis Moore n. sp.

- 8, 9, 10. Front and side views of a brachial valve, cotype. Bed 3 of Chouteau limestone, Snake Den on Little Fabius river, near Newark, Knox County, Missouri; Walker Museum 32153. Moore Collection.
- 15, 18, 19. Side and front views of a pedicle valve, cotype. Same horizon and locality.

Pustula laevicula Moore n. sp.

- 13, 14. Side and front views of a typical pedicle valve, cotype. Sedalia ? limestone, Lovers Leap, Hannibal, Marion County, Missouri; Walker Museum 32109, Moore Collection.

Pustula echinata Moore n. sp.

- 22, 23, 24. Front and side views of a pedicle valve, holotype. Bed 1, Chouteau limestone, Snake Den on Little Fabius river near Newark, Knox County, Missouri; Walker Museum. Moore Collection.
- 25, 26, 27. Front and side view of a specimen from the Chouteau limestone at Chouteau Springs, Pettis County, Missouri; Walker Museum 9825, Sampson Collection.

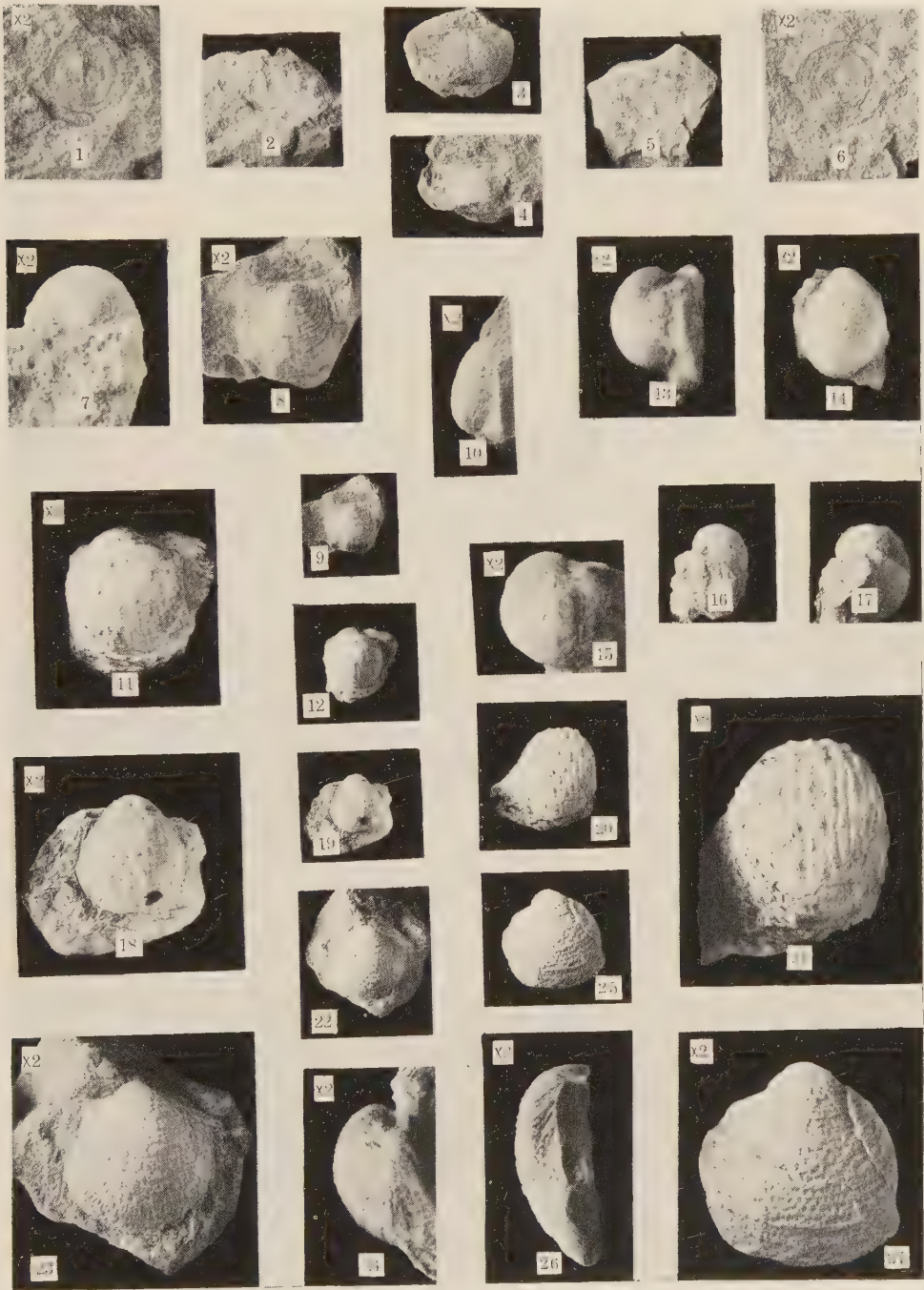


PLATE XII

PLATE XII

Cranaena occidentalis (Miller)

- 1, 2, 3. Brachial and lateral views of a typical specimen from the Chouteau limestone, Fettis County, Missouri. Sampson Collection. W. M. 9716.
- 4, 5, 6. Brachial and lateral views of a specimen from the Chouteau limestone. Bed 2, Snake Den on Little Fabius river, near Newark, Knox County, Missouri. Moore Collection. W. M. 32112.

Eumetria swallowi Moore n. sp.

- 7, 8. Brachial valve; holotype. Chouteau limestone, one-fourth mile above Snake Den on Little Fabius river, near Newark, Knox County, Missouri. Moore Collection. W. M. 32154.

Cranaena hannibalensis Moore n. sp.

9. Pedicle valve; cotype. Hannibal formation, Louisiana, Missouri. Weller Collection. W. M. 32105.
10. Brachial view of cotype. Same horizon and locality.

Spirifer vantuyli Moore n. sp.

- 11, 15. Side and front views of a typical pedicle valve; cotype. Chouteau limestone, Kiesinger Bluff, north of Warsaw, Benton County, Missouri. Moore Collection. W. M. 32115.
- 12, 13. Posterior and front views of a brachial valve; cotype. Same horizon and locality.
- 14, 16. Cardinal and front views of a pedicle valve; cotype. Same horizon and locality.

Spirifer buehleri Moore n. sp.

- 17, 18, 23. Cardinal, front and side views of a pedicle valve; cotype. Reeds Spring limestone, about 10 feet below base of Grand Falls chert, one-fourth mile west of Grand Falls on Shoal creek, six miles south of Joplin, Missouri. Moore Collection. W. M. 32121.
19. Front view of a pedicle valve; cotype. Same horizon and locality.

Spirifer piersonensis Moore n. sp.

- 20, 21, 22. Brachial and lateral views of the holotype. Pierson limestone on Little Sac river, nine miles northeast of Springfield, Greene County, Missouri. Moore Collection. W. M. 32116.



PLATE XIII

PLATE XIII

Sphenotus extensus Moore n. sp.

- 1, 2. Front and hinge views of a typical right valve; cotype. Hannibal formation, Louisiana, Pike County, Missouri. Weller Collection. W. M. 32106.
3. Front view of a well preserved left valve; cotype. Same horizon and locality.

Grammysia welleri Moore n. sp.

- 4, 5, 6. Front and side views of the holotype. Hannibal sandstone, Louisiana, Pike County, Missouri. Weller Collection. W. M. 32102.

Aganides compressus Moore n. sp.

- 7, 8. Side view of the holotype, and drawing of suture. Louisiana limestone, Hamburg, Calhoun County, Illinois. Moore Collection. W. M. 32117.

Schellwienella ? sp.

9. Brachial valve of a well preserved specimen from the Chouteau limestone, Snake Den on Little Fabius river, near Newark, Knox County, Missouri. Moore Collection.

Martinia ? sp.

10. Pedicle valve from the Hannibal formation north of Rockport, Pike County, Illinois. Moore Collection. W. M. 32100.

Sphenotus glaber Moore n. sp.

- 11, 12. Internal mold of a right valve; cotype. Hannibal formation, Louisiana, Pike County, Missouri. Weller Collection. W. M. 32107.
- 13, 14. A well preserved left valve; cotype. Same horizon and locality.

Streblopteria lirata Moore n. sp.

15. A small left valve; cotype. Hannibal formation, Louisiana, Pike County, Missouri. Weller Collection. W. M. 32103.
16. A right valve; cotype. Same horizon and locality.

Cyrtoceras caniniforme Moore n. sp.

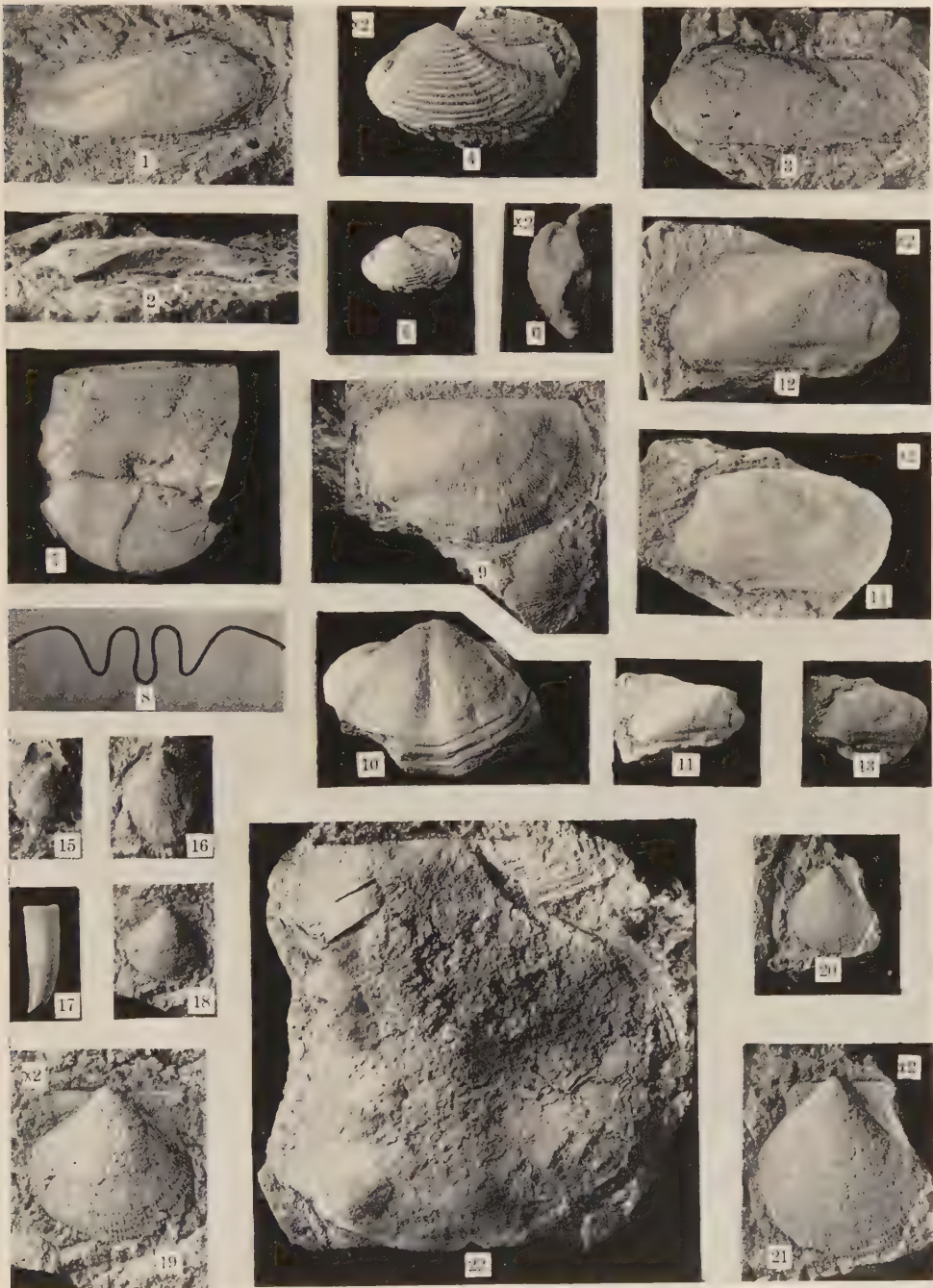
17. Side view of the holotype. Chouteau limestone, one-fourth mile above Snake Den on Little Fabius river, near Newark, Knox County, Missouri. Moore Collection. W. M. 32111.

Aviculopecten welleri Moore n. sp.

- 18, 19. A left valve; cotype. Hannibal formation, Louisiana, Pike County, Missouri. Weller Collection. W. M. 32104.
- 20, 21. A left valve; cotype. Same horizon and locality.

Aviculopecten planulatus Moore n. sp.

22. A right valve; the holotype. Sedalia ? limestone, Hannibal, Marion County, Missouri. Moore Collection. W. M. 32108.



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